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PACE Report No. 87-5

A STUDY OF EXPOSURE TO MOTOR GASOLINE HYDROCARBON VAPOURS AT SERVICE STATIONS (PHASE II — SUMMER STUDY)

"Working for a Better Environment"

A STUDY OF EXPOSURE TO MOTOR GASOLINE HYDROCARBON VAPOURS AT SERVICE STATIONS (PHASE II - SUMMER STUDY)

PACE Report No. 87-5

Prepared for PACE by

Members of the PACE Gasoline Exposure Study Task Force

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EXECUTIVE SUMMARY

The Petroleum Association for Conservation of the Canadian Environment (PACE) undertook an evaluation of motor gasoline vapour exposures at service stations within Canada to assist with an assessment of the health risk of gasoline vapours.

The study determined motor gasoline vapour exposure of full-serve attendants (pumpers) and self-serve kiosk operators. Self-serve customer exposure was approximated by short term measurements during automobile refuelling. Area samples were taken at the service station lot lines. Bulk samples of gasoline being pumped were also obtained.

The study consists of three phases; Phase I - pilot, Phase II- summer, and Phase III - winter. This report summarizes Phase II which evaluated exposure to summer grade gasoline vapours during summer weather conditions.

The field sampling was carried out by four PACE member companies. Sampling was undertaken in five Canadian cities; Halifax, Montreal, Toronto, Calgary and Vancouver between June and August 1985. A standardized sampling and analytical protocol using 600 mg charcoal tubes and capillary gas chromatography with flame ionization detection was followed.

The McMaster University Occupational Health Laboratory in Hamilton, Ontario was retained to perform analysis of the charcoal tube samples. The Concord Scientific Corporation in Toronto, Ontario was hired as an independent consultancy firm to ensure that data management and quality assurance aspects of the study were properly addressed. A total of 302 long term samples, 116 short term samples, 29 blanks and 57 bulk samples were submitted for analysis.

The results show that the average airborne concentration of the 55 gasoline components analysed did not exceed one half of the applicable exposure limits. For kiosk operators and pumpers there is a high probability (95%) that their exposure to total hydrocarbons, a measure of total gasoline vapour exposure, is only one third of the gasoline exposure limit. For both pumpers and kiosk operators, the eight hour benzene exposure was found, at the 95% probability level, to be less than the most stringent Canadian and American occupational exposure limits, as were short term benzene exposures.

These results indicate a low probability of gasoline vapour overexposure for the occupations of kiosk operators and pumpers. They also suggest that public exposures to gasoline vapours would be quite low.

In general, the study indicates that current gasoline vapour exposures would not be expected to present a health concern to Canadian service station personnel or service station customers.

RESUME

L'Association pétrolière pour la protection de l'environnement canadien (APCE) a entrepris une évaluation de l'exposition aux vapeurs provenant de l'essence aux stations-service canadiennes dans le cadre d'une évaluation des risques pour la santé présentés par les vapeurs d'essence.

L'étude a déterminé les niveaux d'exposition aux vapeurs d'essence des préposés au service (pompistes) de stations à service complet et des opérateurs de kiosques à libre-service. Les niveaux d'exposition des clients aux kiosques à libre-service ont été estimés en prenant des mesures à court terme au cours du remplissage des voitures. Des échantillons de zone ont été prélevés aux limites des terrains des stations-service. Des échantillons de l'essence pompée ont également été prélevés.

L'étude consiste en trois phases, soit: la Phase I - pilote; la Phase II - été; la Phase III - hiver. Le présent rapport résume la Phase II qui a comporté l'évaluation de l'exposition aux vapeurs d'essence d'été au cours des conditions météorologiques estivales.

L'échantillonage sur le terrain a été effectué par quatre compagnies membres de l'APCE. L'échantillonnage s'est fait dans cinq villes canadiennes, soit: Halifax, Montréal, Toronto, Calgary et Vancouver, sur la période allant de juin à août 1985. Un protocole uniformisé d'échantillonnage et d'analyse utilisant des tubes de charbon de bois de 600 mg et la chromatographie en phase gazeuse avec détection par ionisation à la flamme fut suivi.

Le laboratoire de l'hygiène professionnelle de l'Université McMaster à Hamilton en Ontario a été chargé de faire l'analyse des échantillons de tubes de charbon de bois. La Concord Scientific Corporation de Toronto en Ontario a été retenue à titre de firme autonome d'experts-conseils afin d'assurer que la gestion des données et l'assurance de la qualité soient envisagées d'une manière satisfaisante. Un total de 302 échantillons à long terme, 116 échantillons à court terme, 29 échantillons-témoins et 57 échantillons d'essence ont été analysés.

Les résultats démontrent que la concentration atmosphérique moyenne des 55 composants d'essence analysés ne dépassait pas la moitié des limites d'exposition admissibles. Il y a une forte probabilité (95%) que l'exposition globale aux hydrocarbures, une mesure de l'exposition totale aux vapeurs d'essence, éprouvée par les opérateurs de kiosques et les pompistes ne s'élève qu'au tiers de la limite d'exposition à l'essence. Pour ce qui est des opérateurs de kiosques et des pompistes, on a constaté que, à un niveau de vraisemblance de 95%, l'exposition du benzène sur une période de huit heures était inférieure aux limites professionnelles les plus strictes en vigueur au Canada ou aux Etats-Unis, comme c'était d'ailleurs le cas pour les expositions à court terme au benzène.

Ces résultats indiquent une faible probabilité de surexposition aux vapeurs d'essence pour les opérateurs de kiosques et les pompistes. Ils suggèrent en outre que les niveaux d'exposition de la population aux vapeurs d'essence seraient très bas.

En général, l'étude indique que les niveaux actuels d'exposition aux vapeurs d'essence ne devraient pas présenter de risques pour la santé du personnel ou des clients des stations-service au Canada.

INTRODUCTION

In 1982 the American Petroleum Institute reported that chronic toxicology studies it had undertaken with wholly vapourized unleaded gasoline had produced dose-related incidences of renal damage and renal cancer in male rats and liver tumours in female mice.[1] This first report in the literature of the chronic toxicity and oncogenicity of gasoline increased concern regarding the potential health hazard of gasoline vapours.

The PACE Health Division reviewed these findings and concluded that the interpretation of the actual risk to humans was difficult to assess in the absence of good epidemiological data and because of the limited availability of human gasoline exposure data, particularly in Canada. During this review, the Health Division identified an additional need; to ensure that the gasoline pump exemption from the Regulation regarding Benzene made under the Ontario Occupational Health and Safety Act was valid. Therefore, the "Study of Exposure to Motor Gasoline Hydrocarbon Vapours at Service Stations" was undertaken to assess service station attendants' and self-serve customers' exposure to gasoline vapours during normal activities.

The study included three phases, namely; Phase I - pilot study (preliminary), Phase II - summer study, and Phase III - winter study. The field work was carried out by four PACE member companies; Esso Petroleum Canada, Petro-Canada, Shell Canada Limited, and Texaco Canada Inc. A standardized sampling protocol was followed. Both area levels and personal exposure levels of gasoline vapours were measured at self-service outlets in five cities across Canada - Halifax, Montreal, Toronto, Calgary and Vancouver. An outside laboratory was hired for the analytical work. A consulting firm was retained to ensure that the data management and the quality assurance aspects were properly addressed.

This document is a report of Phase II, the summer study of gasoline vapour exposure at service stations.

METHOD

Field Sampling

Based on the results of a pilot study[2] carried out in April 1985, the sampling program was performed using a standardized 600 mg charcoal tube sampling protocol. The sampling pumps were calibrated at 0.050 LPM for long term samples and 1 LPM for short term samples. Field data were collected on a standardized industrial hygiene sampling data sheet. For this summer phase study all samples were taken between June 10, 1985 and August 16, 1985 when summer grade gasoline was available. Appendix 1, Air Sampling Method for Study of Exposure to Motor Gasoline Hydrocarbon Vapours, contains details of this method and a sample field

data sheet.

Five Canadian cities; Halifax, Montreal, Toronto, Calgary and Vancouver were chosen as sites for the sampling program in order to obtain a good cross section of geographic and climatic variations. The sampling program carried out in each city by each of the four participating companies consisted of:

Self-serve Stations:
- Three long term personal samples (8 hour) - kiosk operator
- Four area samples (8 hour) at north, south east and west property lines
- One blank

Full-serve Stations:
- Four long term personal samples (8 hour) - pumper
- Four area samples (8 hour) at north, south, east and west property lines
- Six short term personal samples (10-15 min.) during fill-ups with gasoline:
  - 2 regular leaded gasoline
  - 2 regular unleaded gasoline
  - 2 super unleaded gasoline
- One blank

It should be noted that the short term personal samples consisted of monitoring hydrocarbon exposure during a series of gas tank fill ups until at least ten minutes but not more than fifteen minutes had elapsed. Therefore, one short term sample represented gas fill up service to several customers (usually 3-5) over an actual time period which was substantially greater than 15 minutes. The reported short term exposures then, would be significantly higher than the pumper's actual short term exposure as normally defined by the American Conference of Governmental Industrial Hygienists. This is because in any given 15 minute period only one or two fill ups would usually take place. The effect of lowered concentrations during non-fill activities (credit payments, exchange of cash, window cleaning, etc) would result in a lower exposure in our 15 minute exposure period than that of the multiple fill ups used to represent short term exposures in this study.

The total number of air samples in the sample plan was 460. The sample plan also called for three bulk gasoline samples (regular leaded, regular unleaded and super unleaded) in each city for each company, giving an additional 60 samples.

Analysis

McMaster University Occupational Health Laboratory, which is accredited by the American Industrial Hygiene Association, was retained to analyse both the air samples and the bulk samples. The analytical method used was based on previous work undertaken by Research Triangle Institute, Raleigh, N.C., sponsored by the American Petroleum Institute. The method involves determining up to 55 of the individual gasoline vapour components shown in Table 1 using carbon disulfide desorption and capillary gas chromatography with flame ionization detection. (See Appendix 2, Analytical Method for Study of Exposure to Motor Gasoline Hydrocarbon Vapours, for details).

Quality Assurance and Data Analysis

Concord Scientific Corporation was retained to oversee the quality assurance and data analysis. These aspects were addressed in detail in the Phase I - preliminary report.

RESULTS

A total of 302 long term samples, 116 short term samples, 29 blanks and 57 bulk samples were submitted for analysis. These numbers indicate a fairly low sample loss when compared with the original sample plan of 300 long term samples, 120 short term samples, 20 blanks and 60 bulk samples.

On completion of sample analysis, 3 air samples (1 long term and 2 short term) were removed from the data set due to significant flow control problems in the air sampling pumps. Ten blank samples were found to be contaminated and rejected before the data were analysed. The blank value used to correct the long term, short term and area samples was based on an average of the values for 19 charcoal tubes.

The mean concentrations of the long term personal samples for kiosk operators and pumpers are shown by individual components in Figure 1. Note that the concentration axis is logarithmic. The notations TLV-TWA and TLV-STEL refer to Threshold Limit Value - Time Weighted Average and Threshold Limit Value - Short Term Exposure Limit of the American Conference of Governmental Industrial Hygienists.[3]

The median concentrations of the long term personal samples for kiosk operators and pumpers are illustrated by individual components in Figure 2.

A graph of the mean concentrations of the short term personal samples by individual components for the pumper while pumping the three types of gasoline is found in Figure 3.

Figure 4 illustrates the median concentrations by individual

components for the short term personal sample data.

Figure 5 shows the mean concentrations of the area samples at both full-serve and self-serve stations by individual components while Figure 6 indicates the median concentration again by individual components, for these same area samples.

The mean concentrations by carbon number and by hydrocarbon type of the various categories of samples are graphically illustrated in Appendix 3, Mean Airborne Concentrations by Carbon Number and Hydrocarbon Group.

Some of the more important airborne gasoline components were examined individually. The frequency distribution of benzene, isopentane, n-pentane, n-hexane and total hydrocarbons are illustrated for long term, short term and area samples in Figures 7,8,9,10 and 11 respectively. These particular components can also be reported by the city where the samples were taken and by the sample type, as shown in Figures 12-14 for benzene, and Figures 15-17 for the total hydrocarbons. Further descriptive statistics for all the samples are found in Appendix 4, Detailed Descriptive Statistics of Sample Results.

Table 2 reports on the percent benzene in the three types of bulk gasoline samples taken in the five cities. Additional analytical data for these bulk samples are tabulated in Appendix 5, Bulk Gasoline Sample Composition.

DISCUSSION

Field Samples

The mean concentrations of gasoline components for which Threshold Limit Values® (TLV's) have been established by the American Conference of Governmental Industrial Hygienists (ACGIH) did not exceed one half of the applicable limit for long term and short term samples (Table 3). In terms of exposure to total gasoline vapours, the mixture of components in gasoline does not lend itself easily to a TLV® mixture calculation. Therefore, the total hydrocarbons as the sum of the individual components was used for comparison with the gasoline TLV®, since this was believed to give the best indicator of overall exposure. The mean concentration of total hydrocarbons did not exceed one-third of the gasoline TLV®.

The above comparisons certainly suggest that there is a low probability of gasoline vapour overexposure for the occupations of kiosk operator and pumper. These personal sample results are generally consistent with the information available in the published literature.[4-11]

This data would also indicate that public exposure to gasoline

vapours is quite low. This conclusion is based on an estimate of public exposure of less than that of one short term sample per week, since one short term sample represents several fill ups as outlined in Appendix 1.

The individual gasoline components data for long term, short term and area samples are generally lognormally distributed. Figures 7 through 11 illustrate this distribution for benzene, isopentane, n-pentane, n-hexane and total hydrocarbons. The other gasoline vapour components have a similar distribution.

Using the raw data, geometric means and geometric standard deviations for long term and short term personal samples were derived for benzene and total hydrocarbons and used to develop the distributions shown in Figures 18 and 19. Again, these distributions illustrate the lognormal nature of the data.

The area samples represent background hydrocarbon concentrations from a variety of sources in the five cities where the samples were taken. The area sample results were less than one-tenth of the applicable permissible concentrations as generally applied in the workplace.

If one inspects exposure to the various types of gasolines (regular leaded, regular unleaded, and super unleaded) as seen in the mean and median airborne concentrations of the short term personal samples, Figures 3 and 4, there is no readily discernible difference in exposures among the three types of gasoline. One cannot exclude the possibility of significant carry over of gasoline vapours from a pump where one grade of gasoline was being dispensed to a pump where another grade was being dispensed and the pumper was being monitored. Tironi[9] also did not note compositional difference for super and regular gasoline refuelling vapours for a study of a dispensing operation where only one grade of fuel was present during each measurement.

Figures 20,21 and 22 show the weight percent composition of the bulk gasoline samples and the mean short term personal airborne samples by hydrocarbon group for the three types of gasoline. These figures again show the similarity among the exposures measured for the three grades of gasoline.

There are clear compositional differences between the bulk sample and the airborne sample values. Gasoline vapour predominantly consists of n-paraffins and isoparaffins, whereas the bulk gasoline samples contain fewer n-paraffins and more isoparaffins and aromatics. These figures also suggest that n-paraffins and olefins readily evaporate from bulk gasoline whereas other hydrocarbon groups, particularly the aromatics, are less readily found in gasoline vapour, presumably due to higher boiling points.

Figures 23,24 and 25 illustrate the weight percent composition of bulk gasoline and airborne samples for the three types of gasoline by

the individual components analysed. These figures once again illustrate the variation between the bulk gasoline sample composition and the airborne sample composition. These figures also more clearly point out the effect of boiling point on sample composition; the airborne samples contain more of the lower boiling point hydrocarbons than the bulk gasoline samples.

A review of the graphs of airborne concentrations of vapour versus the carbon number of the various gasoline vapour components in Appendix 3 suggests that C4, C5 and C6 components are the most prevalent components of gasoline vapour. The C3 components of gasoline may well be under represented in these samples since the preliminary study showed significant breakthrough of the propane components. Interestingly, the kiosk operator and area samples have more of the heavier vapour components in comparison to the pumper samples. One possible explanation is that the lighter components, C3 and C4, are dispersed more readily into the atmosphere than the heavier components.

Of particular interest are the benzene results since benzene is a suspect human carcinogen according to the ACGIH[3] and a known human carcinogen according to several other authorities quoted in the recent United States Occupational Safety and Health Administration (OSHA) Rule on Occupational Exposure to Benzene.[12] The benzene data reported here were therefore subjected to additional scrutiny.

Accordingly, the data were compared with the most stringent Canadian standard for benzene exposure, that of the province of Ontario; 16mg/m^3 time-weighted average exposure limit with a view to achieving 3.2mg/m^3 and 48mg/m^3 maximum concentration. The latter is actually a 15 minute short term exposure limit due to the mandated sampling methodology. The data were also compared to the new OSHA permissible exposure level (PEL) for benzene of 3.2 mg/m^3 and to the new OSHA short term exposure of 16 mg/m^3. All these exposure limits are considerably below the current ACGIH TLV's® of 30 mg/m^3 TLV-TWA and 75 mg/m^3 TLV-STEL.

There is a 95% probability that short term personal benzene exposure is equal to or less than 10.7 mg/m^3, which is significantly below the Ontario limit, and is also less than the new OSHA short term exposure limit. It should be noted that service stations are exempt from the OSHA benzene rule.

For the long term personal samples of pumper exposure to benzene there is a 95% probability that benzene exposure is equal to or less than 2.65 mg/m^3 which is below that Ontario time-weighted average exposure limit and the OSHA PEL. The 95% probability value of kiosk operators is 2.61 mg/m^3, which again is below the Ontario time-weighted average benzene exposure limit.

Table 2 which summarizes the benzene content of bulk gasolines, and Figure 13 which shows the short term airborne concentrations of benzene by city, indicate that city is an important determinant of

benzene content in bulk gasoline. In an effort to establish a relationship between benzene content of a gasoline sample (liquid) and the airborne concentration of benzene, the percent benzene in the airborne samples was plotted against the percent benzene in the bulk gasoline samples (see Figure 26). There appears to be some relationship between the airborne benzene and benzene in bulk gasoline values. Further data analysis is required to define this relationship.

A review of the series of graphs of gasoline vapour concentrations by city (Figures 12-17) suggests the following: Calgary clearly recorded the lowest airborne concentrations for all components examined, followed by Halifax, Vancouver, Toronto and Montreal. The higher concentrations in Toronto and Montreal are likely a reflection of the greater degree of urbanization in these two cities.

Precision

The duplicate analysis of individual front sections of charcoal tubes provided a measure of the precision of the gas chromatography portion of the sample analysis. The resultant standard deviations by individual components listed in Table 4 are generally within the accepted range for such samples with the exception of the higher concentrations of samples containing propane, butane and isobutane.

Blanks

An analysis of the blank data showed that city of origin had a minimal effect on the average blank level. However, company of origin appeared to affect the extent of contamination on the blank. Blanks from two companies were highly contaminated and were not representative. The application of a criterion of no more than 100 ug of any compound on the front section of the charcoal tube eliminated ten extremely contaminated blanks. By using only those blanks with little contamination, higher air concentrations would be obtained and hence any conclusions drawn from these higher values would be conservative in nature.

Breakthrough

An investigation of the degree of breakthrough of hydrocarbon into the backup section of the charcoal tubes indicated that no samples exhibited significant breakthrough using the following definition of breakthrough:

1. back up section contaminant loading less than or equal to 25% of the front section loading, or

2. if back loading is greater than 25% of front section loading, total analysis is less than twice the detection limit and less than one tenth of the Threshold Limit Value®.

CONCLUSIONS

1. For kiosk operators there is a probability of greater than 95% that full shift exposure to gasoline vapours (measured as a total of the 55 hydrocarbons analysed) is equal to or less than 181 mg/m^3. This value is approximately one-fifth of the current ACGIH TLV-TWA for gasoline, 900 mg/m^3, which has also been adopted by most Canadian jurisdictions.

2. There is a greater than 95% probability that pumpers' full shift exposure to gasoline vapours is equal to or less than 242 mg/m^3. Again, this value is roughly one-fourth of the current ACGIH TLV-TWA for gasoline. This exposure limit has also been adopted by most Canadian jurisdictions.

3. For pumpers and kiosk operators there is greater than 95% probability that full shift benzene exposures will be less than 3.2 mg/m^3, the most stringent Canadian occupational exposure target over an eight hour shift.

4. Based on the reported benzene data we conclude that Ontario regulatory initiatives requiring benzene assessments of full and self-serve gas stations are not justifiable due to the very low benzene exposure for these sites.

5. Full shift exposure to all other reported gasoline vapour components are well below current exposure limits.

6. There is a 95% probability that short term exposure of pumpers to gasoline vapours expressed as total hydrocarbons is equal to or less than 750 mg/m^3, a value which is significantly less than the current ACGIH TLV-STEL, 1500, mg/m^3. This limit has been adopted by most Canadian jurisdictions.

7. There is a greater than 95% probability that the short term benzene exposure of pumpers is equal to or less than 10.7 mg/m^3. This value is only about one-fourth of the Ontario short term limit, 48 mg/m^3, and is less than 16 mg/m^3 the most stringent short term exposure limit, currently in force in the United States.

8. Typical customer gasoline vapour exposure resulting from self-service fill ups several times weekly would be well below the short term exposure concentrations determined in this study. In general then, gasoline vapour exposure would not be expected to present a health concern for the service station customer.

9. Some further resolution of sampling and analytical methodology, particularly for benzene, propane and the lighter gasoline vapour components, is recommended.

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TABLE 1

GASOLINE VAPOUR COMPONENTS

COMPONENT NO.	CHEMICAL NAME	CAS NUMBER	CARBON NUMBER	HYDROCARBON GROUP
1	Propane	74-98-6	3	n-paraffins
2	Isobutane	75-28-5	4	isoparaffins
3	1-Butene	106-98-9	4	olefins
4	n-Butane	106-97-8	4	n-paraffins
5	Trans-2-butene	624-64-6	4	olefins
6	Cis-2-butene	107-01-7	4	olefins
7	3-Methyl-1-butene	563-45-1	5	olefins
8	Isopentane	109-68-2	5	isoparaffins
9	1-Pentene	109-67-1	5	olefins
10	2-Methyl-1-butene	563-46-2	5	olefins
11	n-Pentane	109-66-0	5	n-paraffins
12	Trans-2-pentene	646-04-8	5	olefins
13	2-Methyl-2-butene	513-35-9	5	olefins
14	Cyclopentane	287-92-3	5	cycloparaffins
15	2,3-Dimethylbutane	79-29-8	6	isoparaffins
16	2-Methylpentane	107-83-5	6	isoparaffins
17	3-Methylpentane	96-14-0	6	isoparaffins
18	1-Hexene	592-41-6	6	olefins
19	n-Hexane	110-54-3	6	n-paraffins
20	Trans-3-methyl-2-pentene	616-12-6	6	olefins
21	2,2-Dimethylpentane	590-35-2	7	isoparaffins
22	Methylcyclopentane	96-37-7	6	cycloparaffins
23	2,4-Dimethylpentane	108-08-7	7	isoparaffins
24	2,2,3-Trimethylbutane	464-06-2	7	isoparaffins
25	Cis-4,4-dimethylpentene	762-62-9	7	olefins
26	Benzene	71-43-2	6	aromatics
27	3,3-Dimethylpentane	562-49-2	7	isoparaffins
28	Cyclohexane	110-82-7	6	cycloparaffins
29	2-Methylhexane	591-76-4	7	isoparaffins
30	2,3-Dimethylpentane	565-59-3	7	isoparaffins
31	3-Methylhexane	589-34-4	7	isoparaffins
32	3-Ethylpentane	617-78-7	7	isoparaffins
33	1-Heptene	592-76-7	7	olefins
34	2,2,4-Trimethylpentane	540-84-1	8	isoparaffins
35	n-Heptane	142-82-5	7	n-paraffins
36	Methylcyclohexane and 2,2-Dimethylhexane	108-87-2 590-73-8	7,8	cycloparaffins isoparaffins
37	2,5-Dimethylhexane	592-13-2	8	isoparaffins
38	2,4-Dimethylhexane	589-43-5	8	isoparaffins
39	3,3-Dimethylhexane	563-16-6	8	isoparaffins
40	2,3,4-Trimethylpentane	565-75-3	8	isoparaffins
41	Toluene	108-88-3	7	aromatics
42	2-Methylheptane	592-27-8	8	isoparaffins
43	3,4-Dimethylhexane	583-48-2	8	isoparaffins
44	3-Methylheptane	589-81-1	8	isoparaffins
45	2,2,5-Trimethylhexane	3522-94-9	9	isoparaffins
46	n-Octane	111-65-9	8	n-paraffins
47	Ethylbenzene	100-41-4	8	aromatics
48	m-Xylene	1330-20-7	8	aromatics
49	p-Xylene	1330-20-7	8	aromatics
50	o-Xylene	1330-20-7	8	aromatics
51	n-Nonane	111-84-2	9	n-paraffins
52	Isopropylbenzene	98-82-8	9	aromatics
53	Ethyltoluene	611-14-3	9	aromatics
54	1,3,5-Trimethylbenzene	108-67-8	9	aromatics
55	n-Decane	124-18-5	10	n-paraffins
56	Gasoline as Total Hydrocarbons (THC)		-	-

TABLE 2

PERCENT BY WEIGHT BENZENE IN BULK GASOLINE SAMPLES

	VANCOUVER	CALGARY	TORONTO	MONTREAL	HALIFAX
REGULAR UNLEADED	0.1	0.1	0.1	2.0	2.6
	2.2	0.6	2.6	2.6	4.0
	2.3	0.6	2.8	2.9	4.2
	2.4	0.6	5.2		4.3
REGULAR LEADED	1.9	1.7	1.0	.08	1.6
	1.9	1.9	1.4	1.6	2.2
	2.2	1.9	2.8	1.7	2.2
	3.3	2.0	3.2		2.3
SUPER UNLEADED	0.4	0.1	1.1	2.3	3.8
	2.0	0.2	1.5	2.8	4.1
	2.2	0.3	1.7	3.4	4.6
	2.4	0.9	1.7		4.9

TABLE 3. ESTABLISHED THRESHOLD LIMIT VALUES OF SOME GASOLINE COMPONENTS IN MG/M^3

CHEMICAL NAME	COMPONENT NUMBER	TLV-TWA	TLV-STEL
n-Butane	4	1900	.
n-Pentane	11	1800	2250
Cyclopentane	14	1720	2580
2, 3-Dimethylbutane	15	1800	3600
2-Methylpentane	16	1800	3600
3-Methylpentane	17	1800	3600
1-Hexene	18	1800	3600
n-Hexane	19	180	.
Benzene	26	30	75
Cyclohexane	28	1015	1300
n-Heptane	35	1600	2000
Methylcyclohexane	36	1600	2000
Toluene	41	375	560
n-Octane	46	1450	1800
Ethylbenzene	47	435	545
m-Xylene	48	435	655
p-Xylene	49	435	655
o-Xylene	50	435	655
n-Nonane	51	1050	1300
1, 3, 5-Trimethylbenzene	54	125	170
Total-Hydrocarbons	56	900	1500

TABLE 4

ANALYTICAL PRECISION BY RANGE FOR DUPLICATE ANALYSIS OF CHARCOAL TUBES
SAMPLE LOADING

	0 - 1 µg/sample			10-20 µg/sample			>10 µg/sample		
	I	II	III	I	II	III	I	II	III
n-Butane	88	0.054	17	95	0.497	3	104	10.666	0
2,3 Dimethylbutane	96	0.094	28	129	0.602	21	26	2.150	11
Isobutane	94	0.042	16	105	0.431	4	79	20.373	3
2,2,3 Trimethylbutane	128	0.052	22	19	0.400	11	0	ND	14
1-Butene	106	0.062	20	91	0.380	4	14	3.167	3
Cis-2-butene	143	0.062	13	97	0.357	2	7	3.811	2
2-Methyl-1-butene	49	0.107	23	61	0.573	7	10	1.220	1
3-Methyl-1-butene	94	0.072	32	69	0.418	10	10	1.553	1
2-Methyl-2-butene	0	ND	0	0	ND	0	0	ND	0
Trans-2-butene	32	0.057	1	63	0.203	1	18	2.152	0
Benzene	157	0.097	32	106	0.462	9	9	1.456	1
Ethylbenzene	302	0.018	19	14	0.092	5	0	ND	1
Isopropylbenzene	179	0.014	43	20	0.087	1	0	ND	0
1,3,5-Trimethylbenzene	207	0.008	23	3	0.112	1	0	ND	0
Cyclohexane	150	0.063	43	49	0.351	1	3	0.385	0
Methylcyclohexane	244	0.043	46	27	0.277	5	0	ND	0
Cyclopentane	131	0.085	55	96	0.578	4	14	1.939	0
Methylcyclopentane	129	0.079	46	125	0.426	6	16	2.536	0
n-Decane	150	0.010	17	2	0.128	8	3	0.290	1
n-Heptane	257	0.036	36	44	0.327	5	1	0.386	0
2-Methylheptane	282	0.025	31	6	0.086	5	0	ND	0
3-Methylheptane	280	0.033	36	8	0.095	5	0	ND	0
1-Heptene	172	0.041	38	33	0.280	1	0	ND	0
n-Hexane	54	0.058	36	133	0.830	2	70	4.522	0
2,2-Dimethylhexane	0	ND	0	0	ND	0	0	ND	0
2,4-Dimethylhexane	275	0.016	25	2	0.055	6	0	ND	6
2,5-Dimethylhexane	265	0.028	38	5	0.049	4	0	ND	6
3,3-Dimethylhexane	258	0.025	42	1	0.047	1	0	ND	4
3,4-Dimethylhexane	197	0.024	43	4	0.261	1	0	ND	4
2-Methylhexane	229	0.035	23	68	0.311	5	4	0.411	6
3-Methylhexane	214	0.053	32	71	0.498	7	5	0.801	6
2,2,5-Trimethylhexane	203	0.017	43	2	0.271	12	0	ND	5
1-Hexene	133	0.081	46	77	0.390	10	8	2.144	4
n-Nonane	93	0.007	12	3	0.148	1	0	ND	0
n-Octane	232	0.023	55	1	0.072	7	0	ND	6
n-Pentane	38	0.079	29	128	0.687	5	124	7.135	2
2,2-Dimethylpentane	196	0.031	16	11	0.215	9	0	ND	22
2,3-Dimethylpentane	230	0.052	23	47	0.317	8	1	4.311	15
2,4-Dimethylpentane	225	0.050	22	48	0.303	7	0	ND	15
3,3-Dimethylpentane	166	0.063	33	28	0.373	9	0	ND	14
3-Ethylpentane	246	0.033	24	28	0.250	9	0	ND	15
2-Methylpentane	98	0.071	23	155	0.411	7	45	2.981	9
3-Methylpentane	142	0.067	21	138	0.390	8	22	2.706	10
2,2,4-Trimethylpentane	167	0.028	15	34	0.190	6	0	ND	4
2,3,4-Trimethylpentane	253	0.022	22	19	0.155	7	0	ND	9
1-Pentene	92	0.080	44	100	0.558	7	23	2.498	8
Cis-4,4-Dimethylpentane	137	0.049	25	26	0.370	14	0	ND	8
Trans-2-pentene	60	0.109	30	89	0.987	7	30	4.202	5
Trans-3-methyl-2-pentene	212	0.038	33	38	0.243	10	0	ND	10
Propane	158	0.092	55	66	1.089	17	13	17.602	4
Isopentane	84	0.062	24	126	0.592	2	112	4.595	3
Toluene	275	0.034	15	76	0.221	4	7	1.190	1
Ethyltoluene	232	0.008	27	3	0.086	4	0	ND	0
m-Xylene	30	0.016	0	0	ND	0	0	ND	0
o-Xylene	299	0.013	18	8	0.085	2	0	ND	1
p-Xylene	311	0.029	15	25	0.162	2	0	ND	1

I = Number of Samples included in calculation
II = Standard Deviation
III = Number of Samples excluded based on 100% difference criterion

Fig. 1. Mean Airborne Concentrations by Components for Long Term Personal Samples

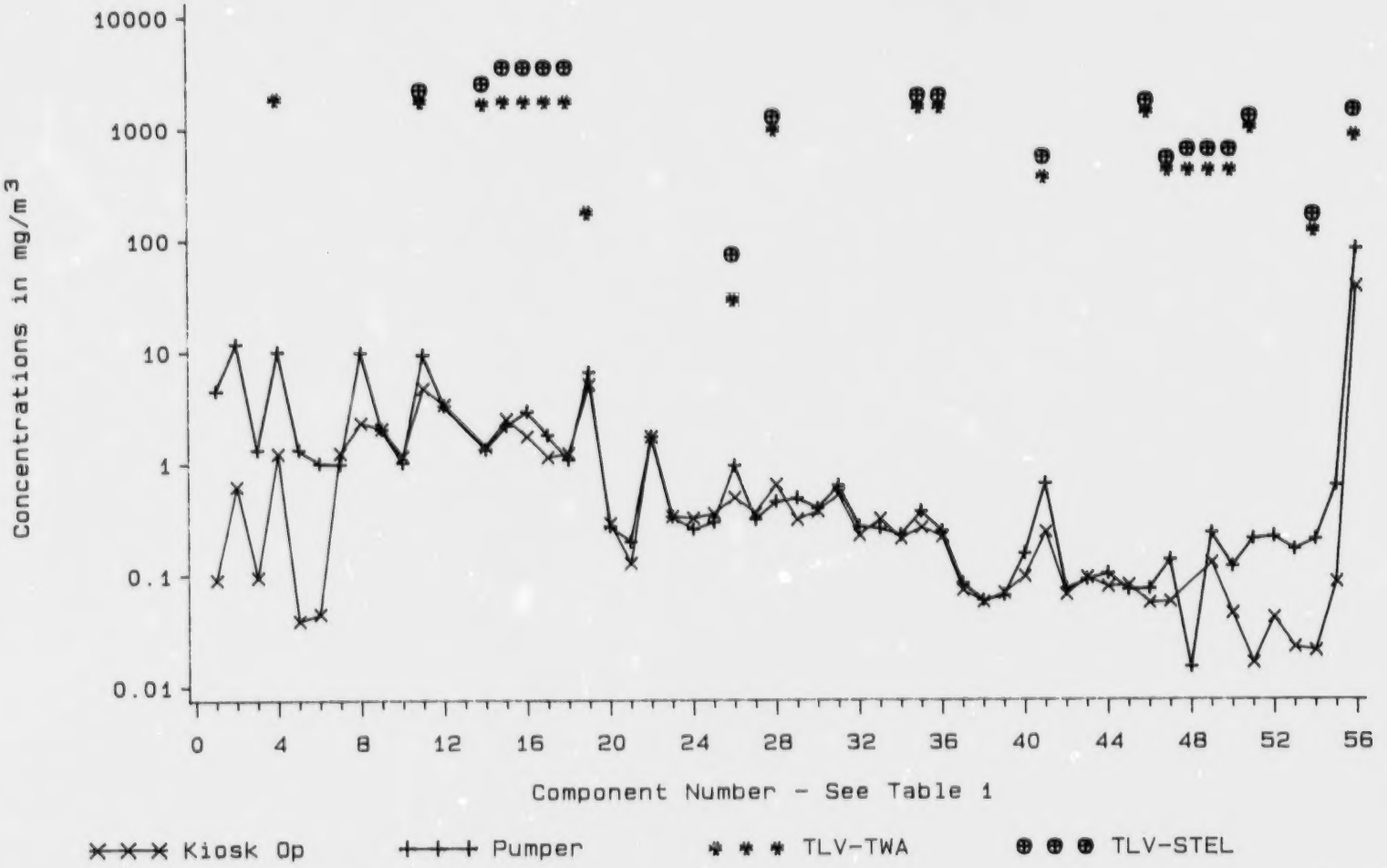


Fig. 2. Median Airborne Concentrations by Components for Long Term Personal Samples

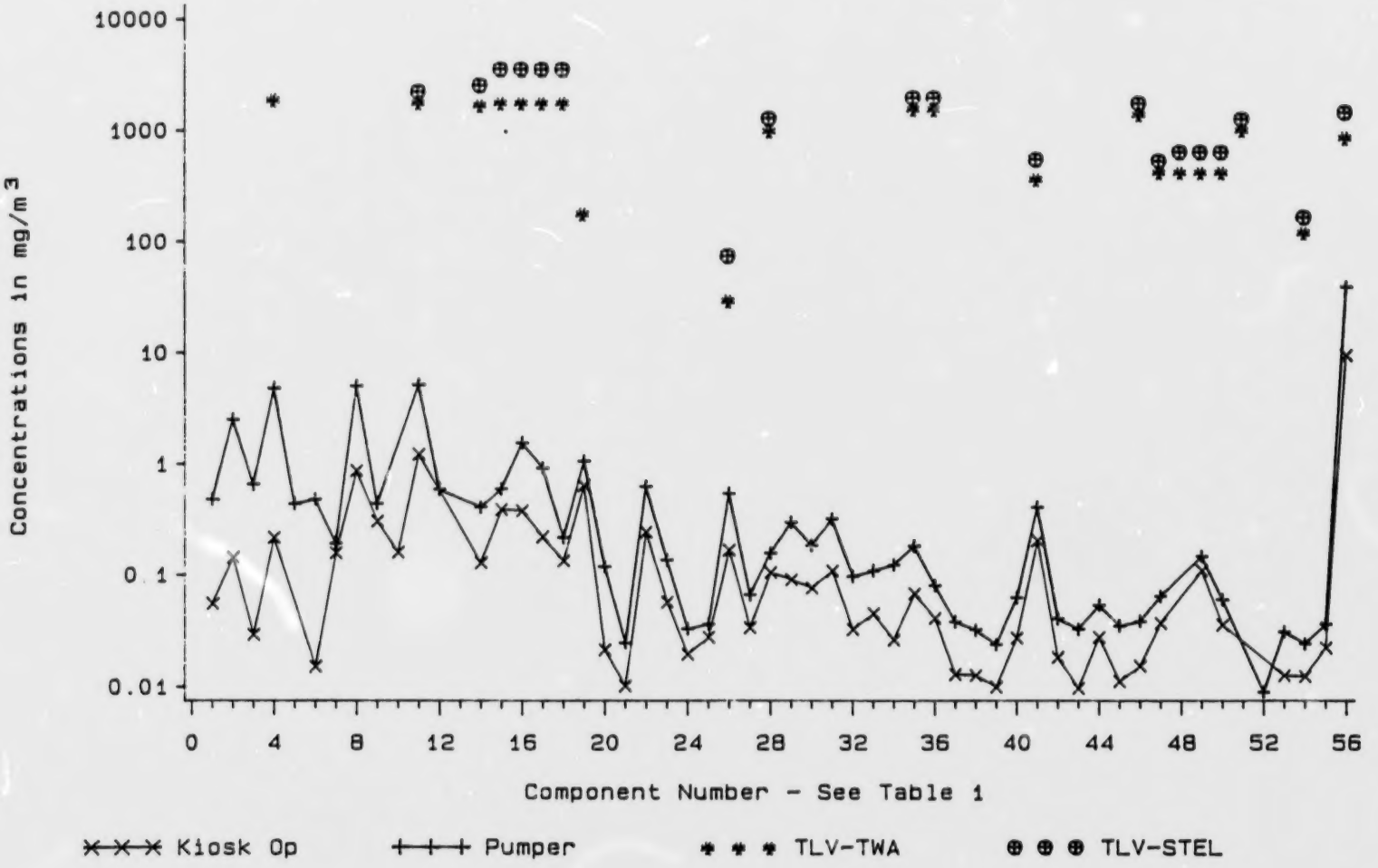


Fig. 3. Mean Airborne Concentrations by Components for Short Term Personal Samples

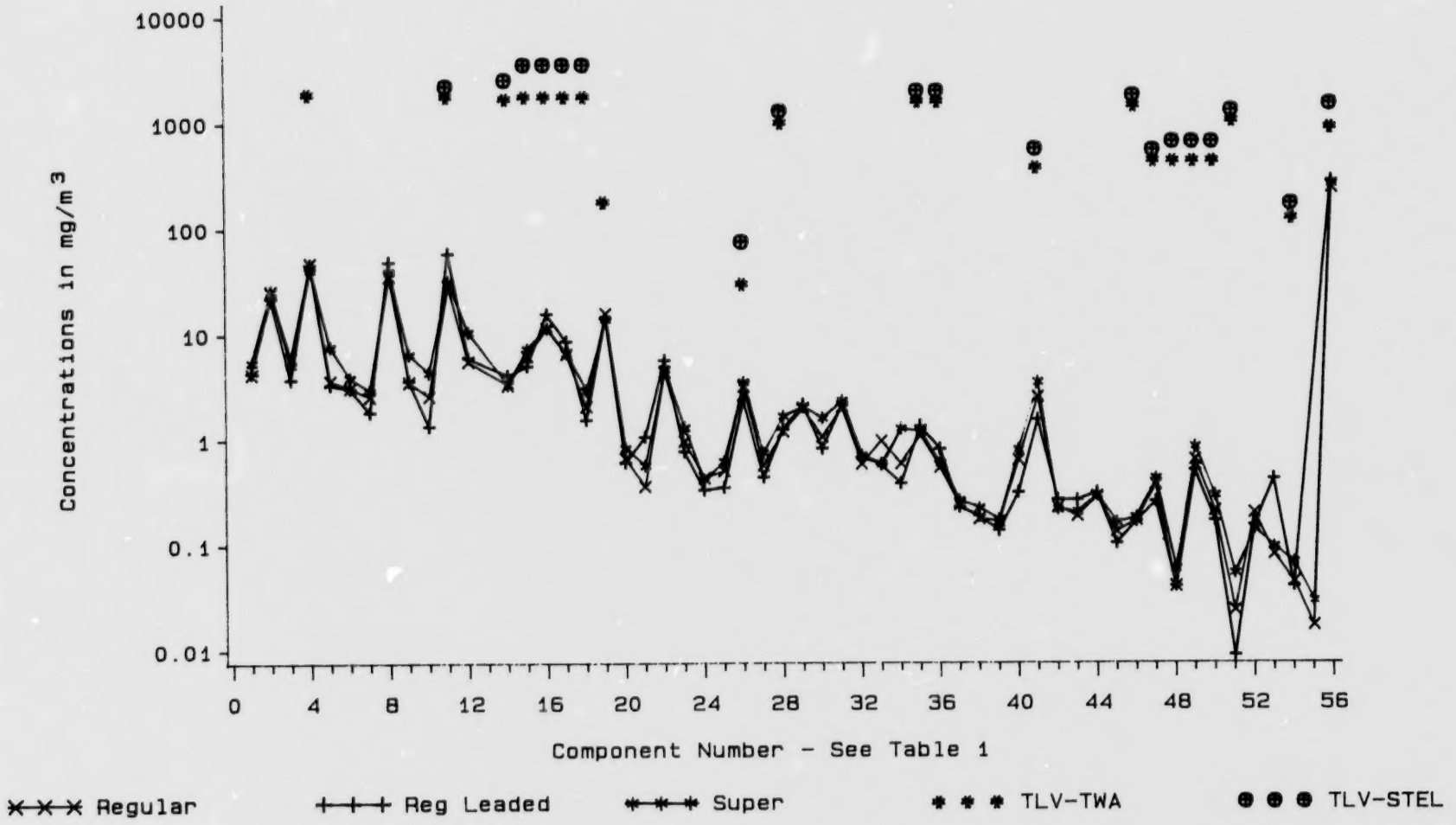


Fig. 4. Median Airborne Concentrations by Components for Short Term Personal Samples

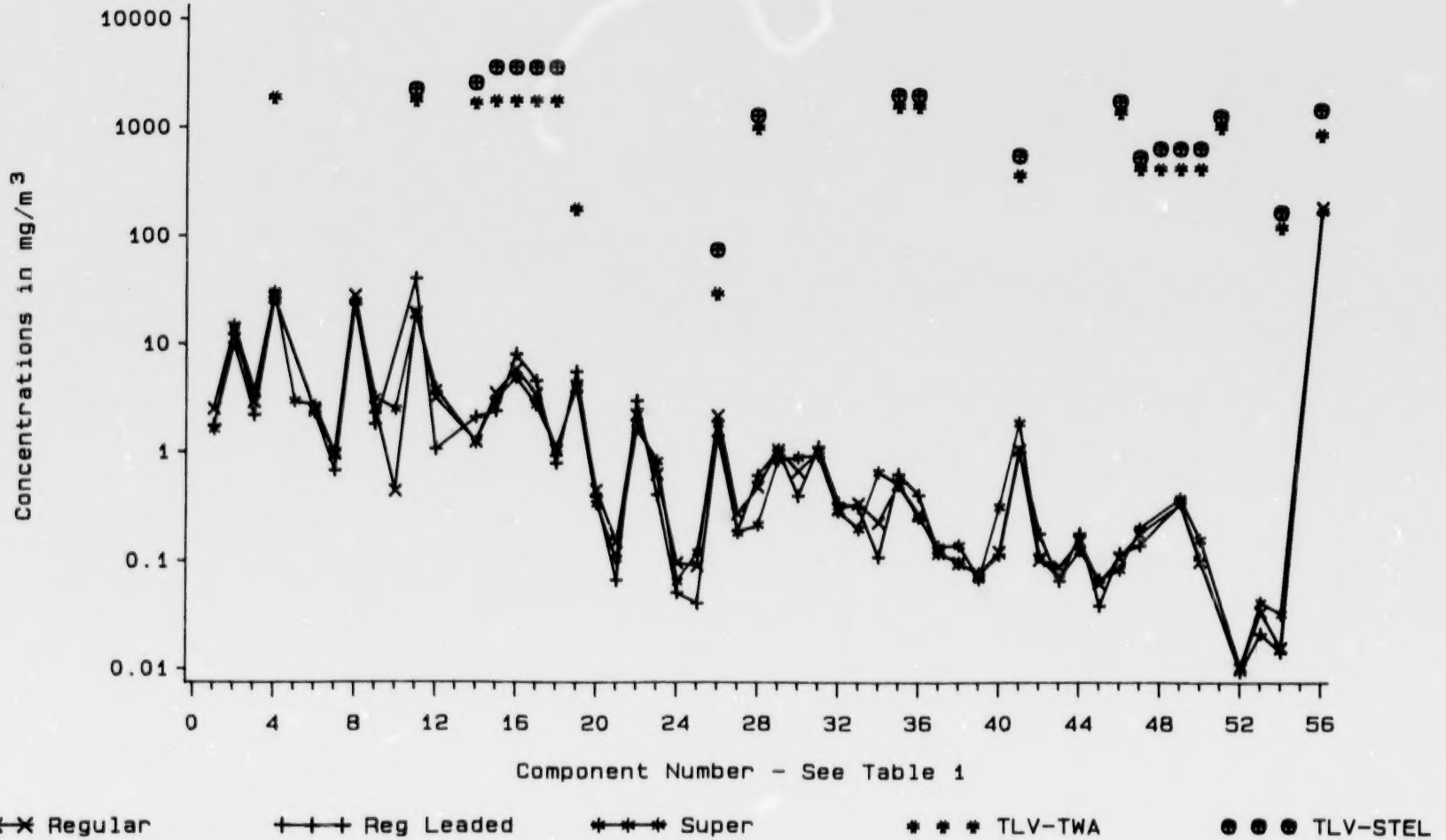


Fig. 5. Mean Airborne Concentrations by Components for Area Samples

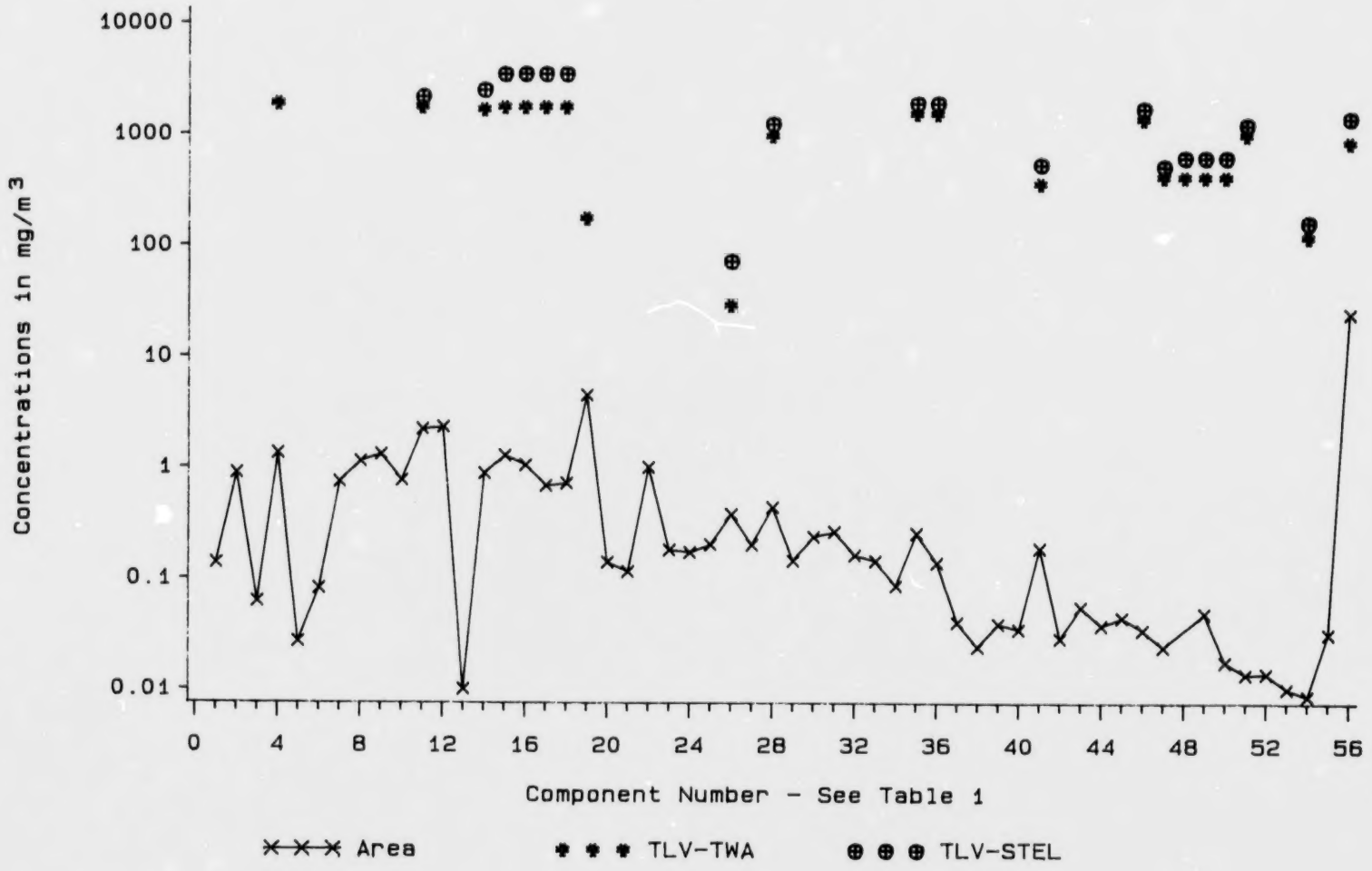


FIG. 6. Median Airborne Concentrations by Components for Area Samples

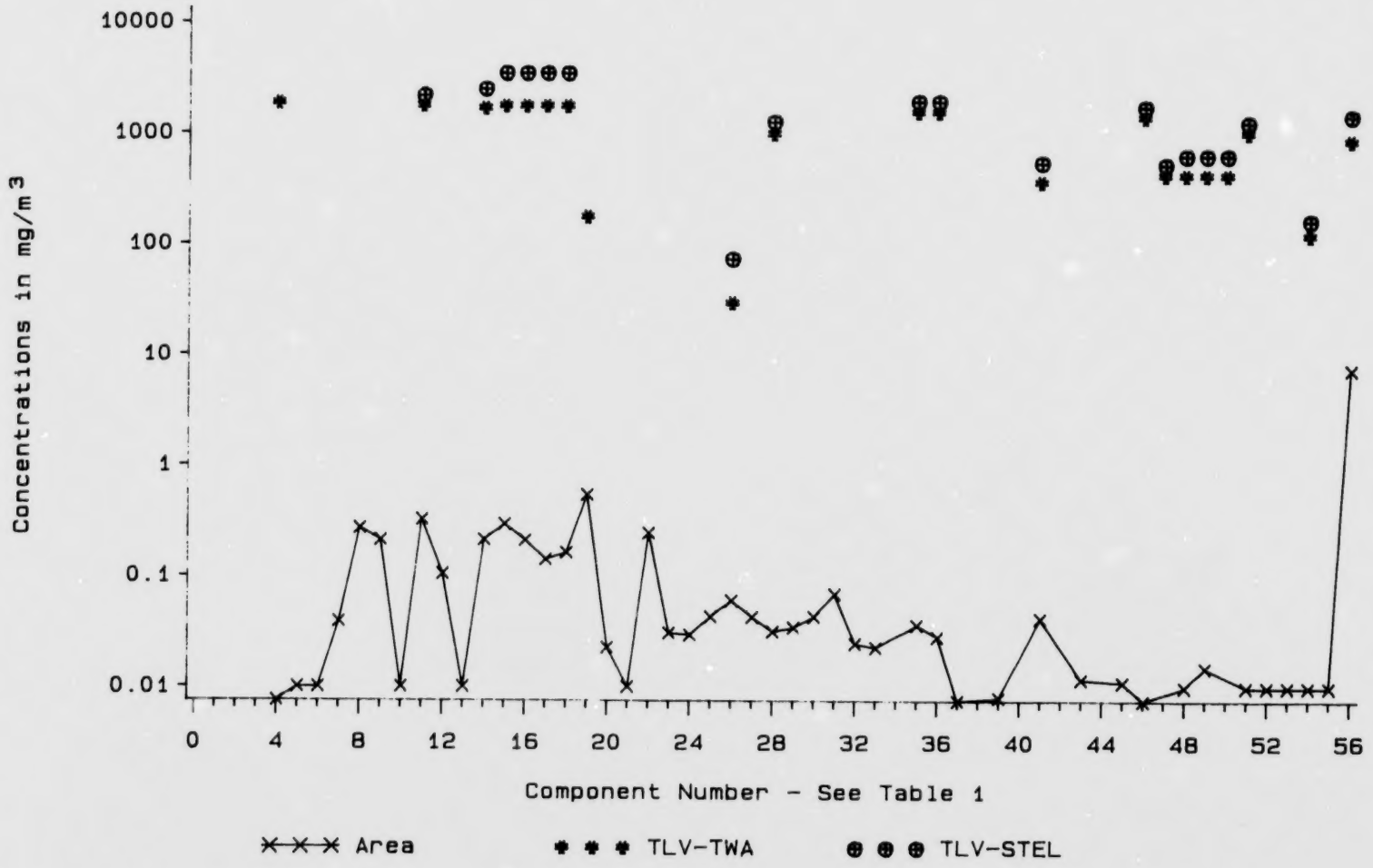


Fig. 7. Frequency Distribution of Airborne Concentrations for Benzene

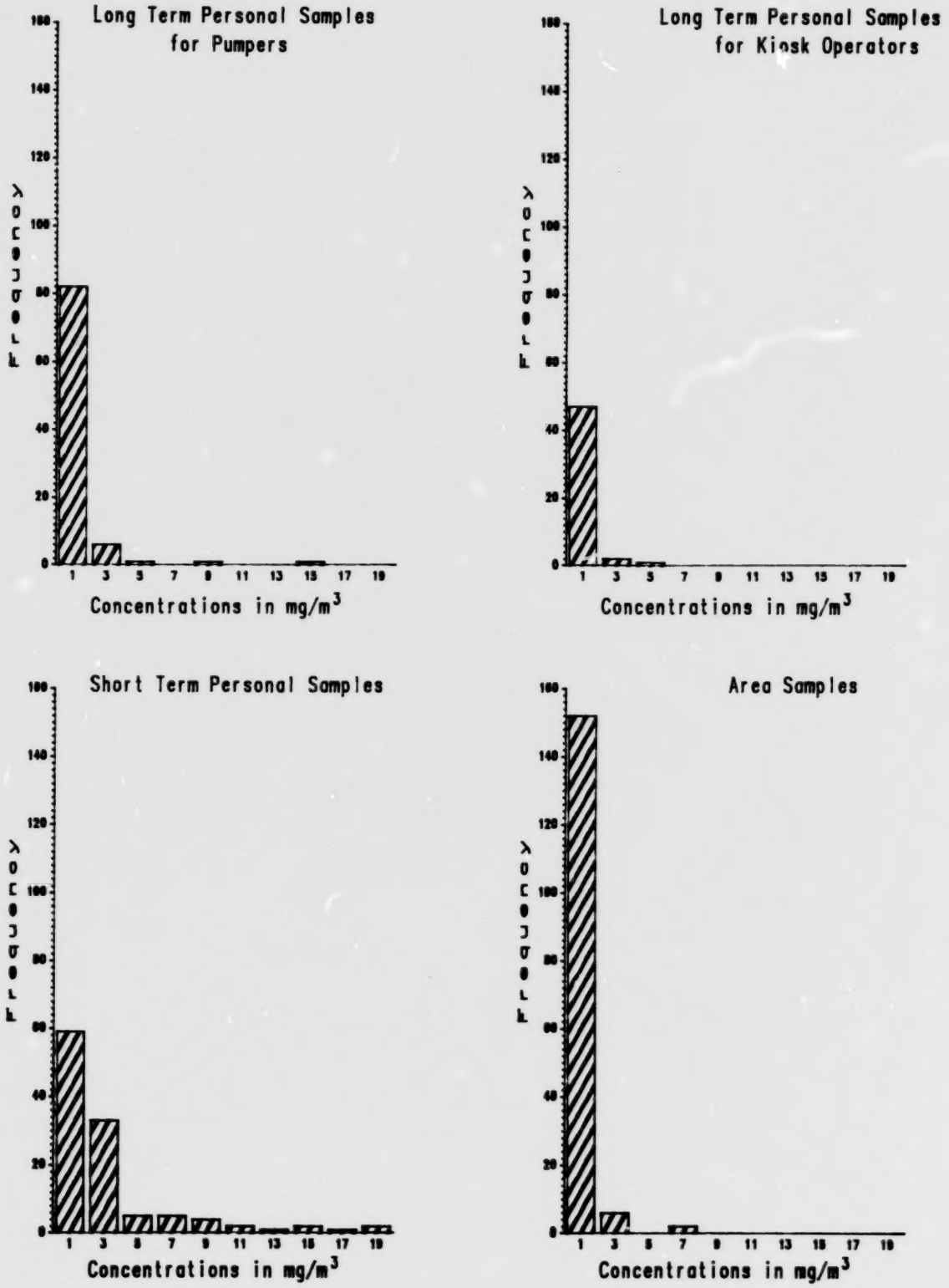


Fig. 8. Frequency Distribution of Airborne Concentrations for Isopentane

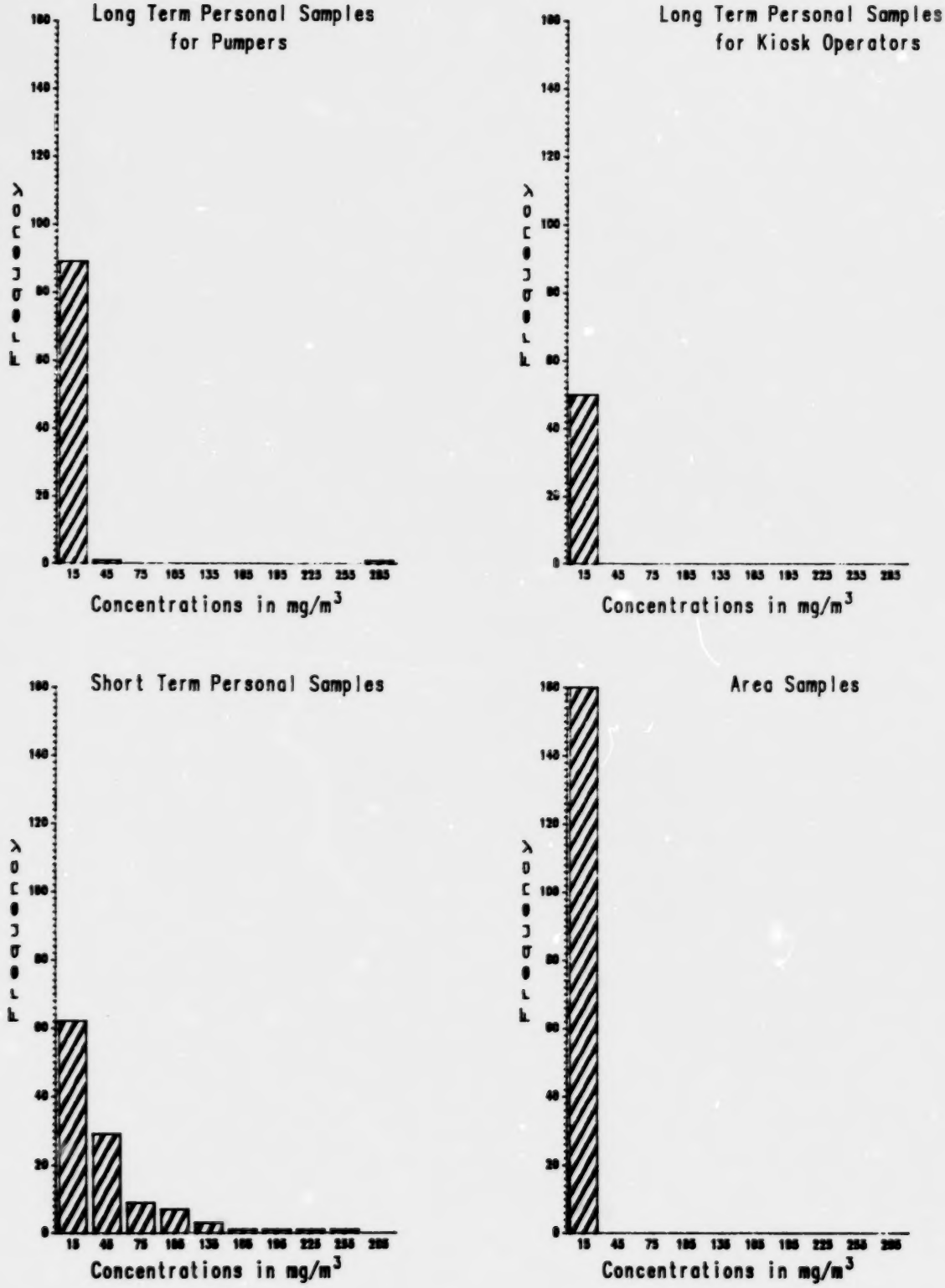

Long Term Personal Samples for Pumpers
Long Term Personal Samples for Kiosk Operators
Short Term Personal Samples
Area Samples
Concentrations in mg/m3

Fig. 9. Frequency Distribution of Airborne Concentrations for n–Pentane

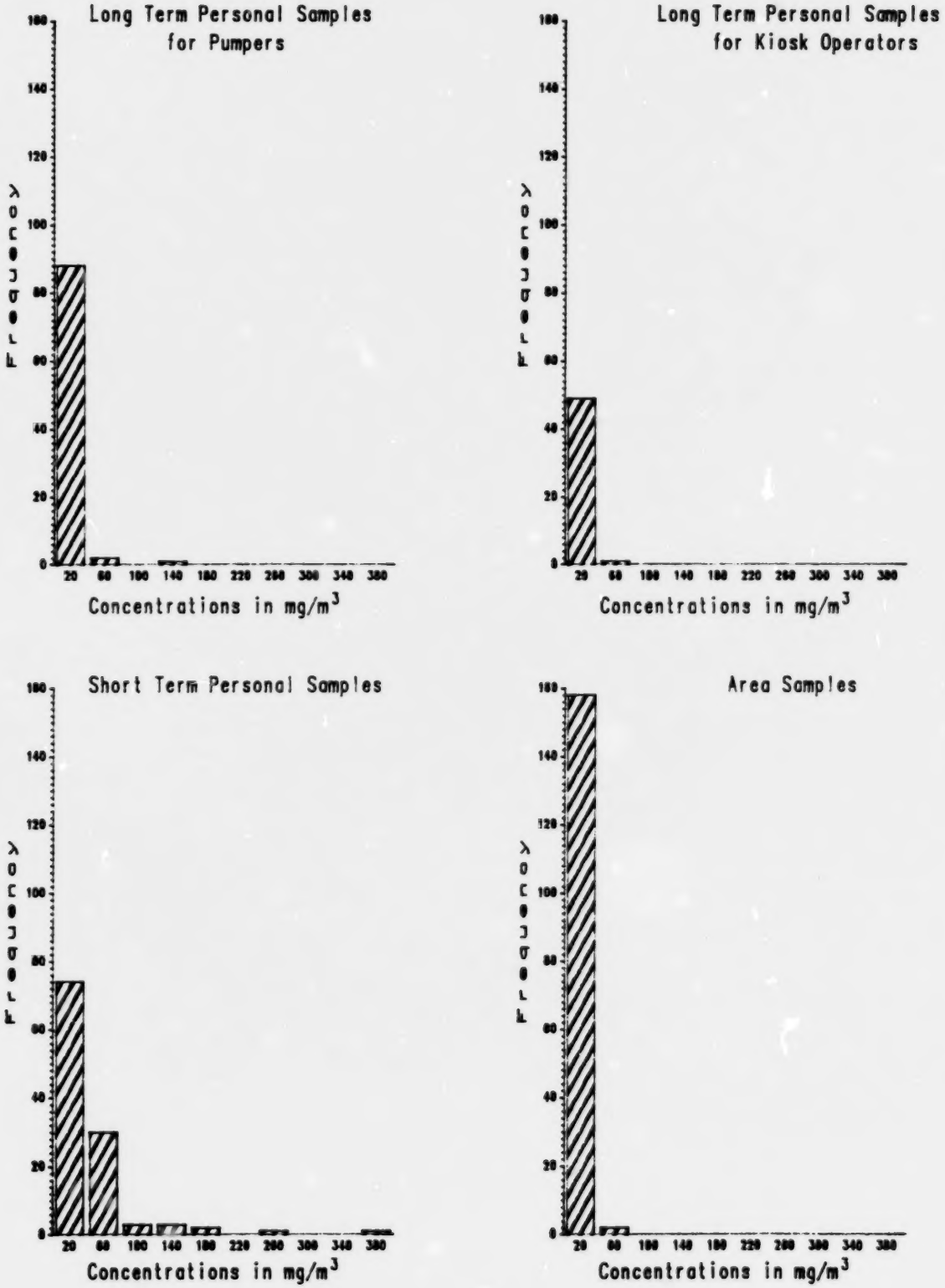


Fig. 10. Frequency Distribution of Airborne Concentrations for n–Hexane

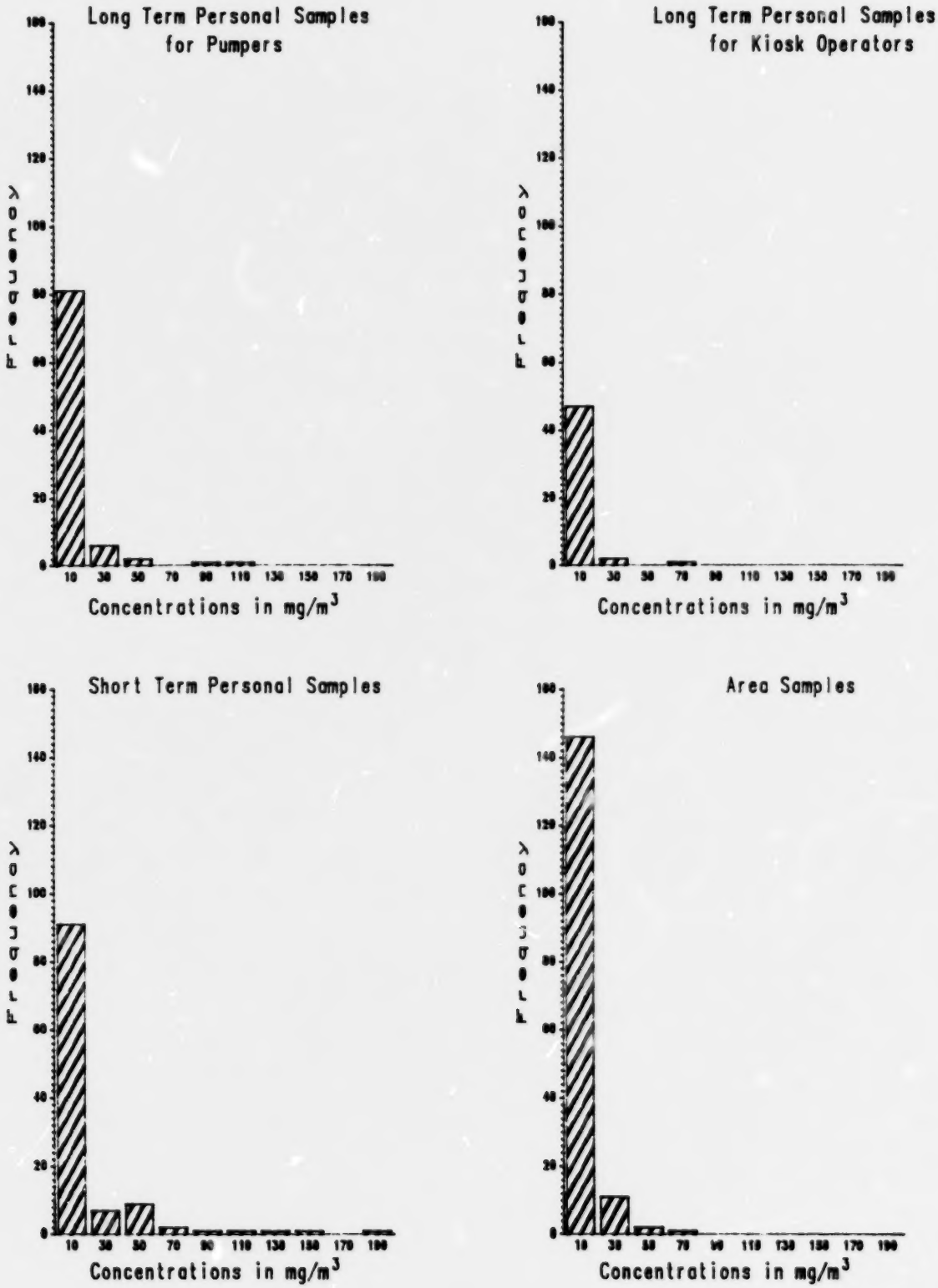
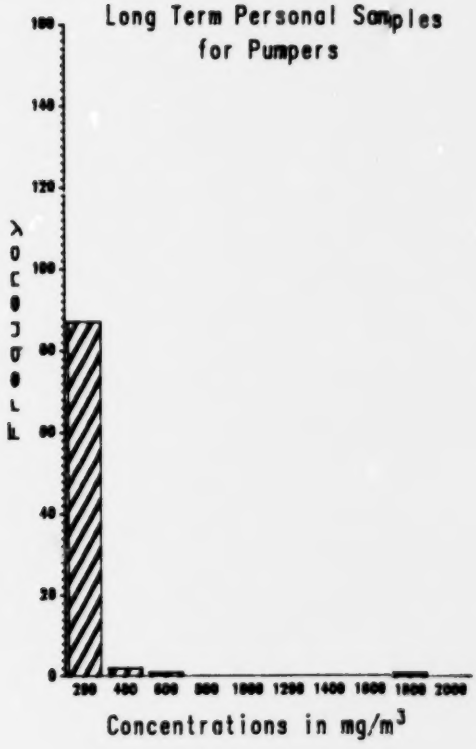
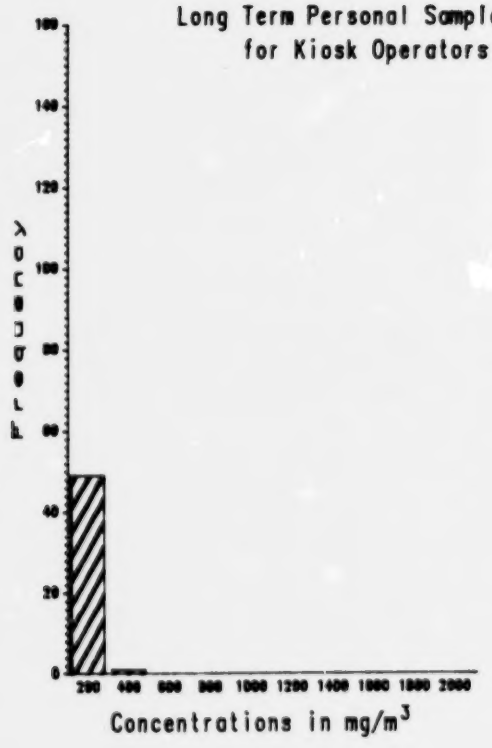
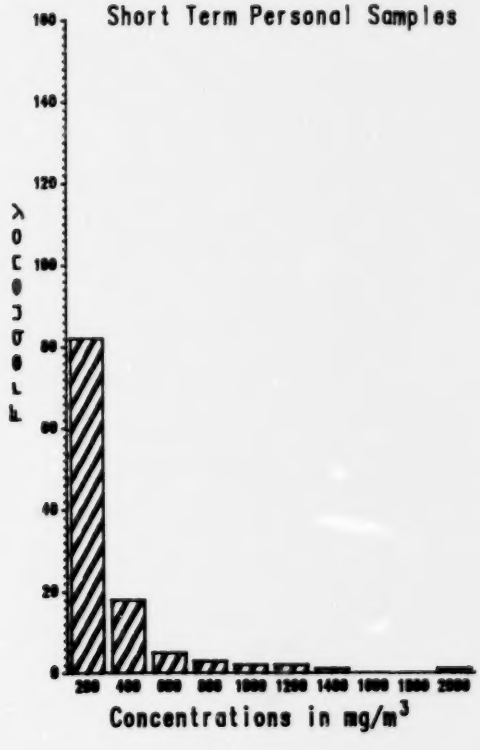


Fig. 11. Frequency Distribution of Airborne Concentrations for Total Hydrocarbons







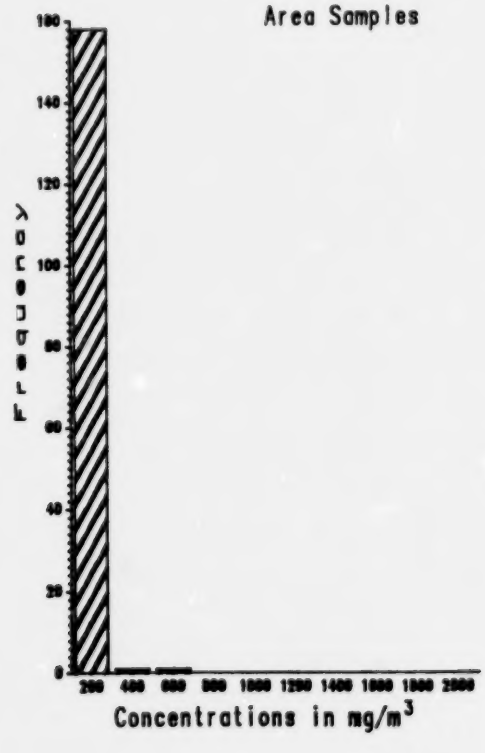


Fig. 12. Comparison of Mean Concentrations of Benzene by Cities for Long Term Personal Samples

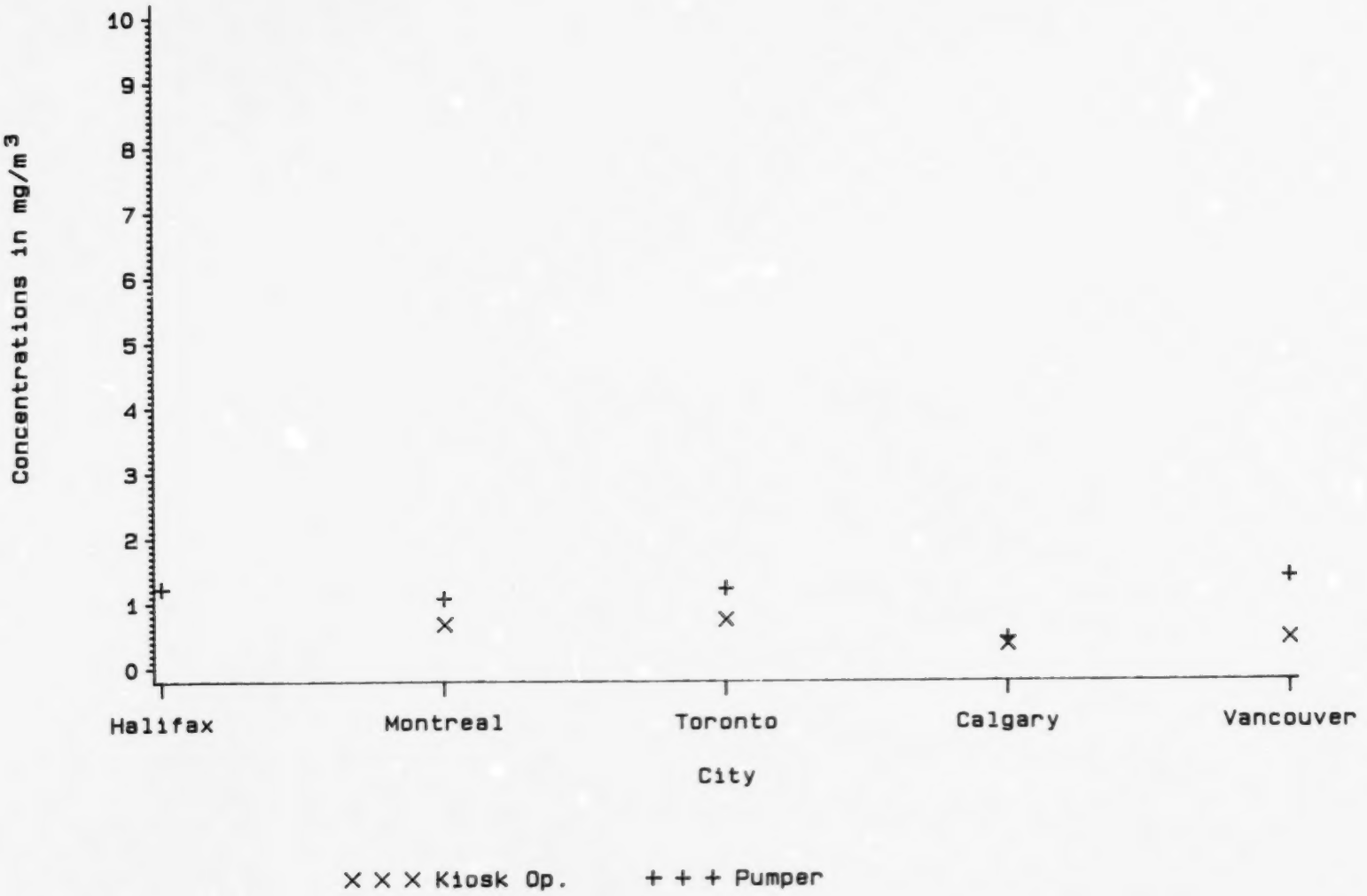


Fig. 13. Comparison of Mean Concentrations of Benzene by Cities for Short Term Personal Samples

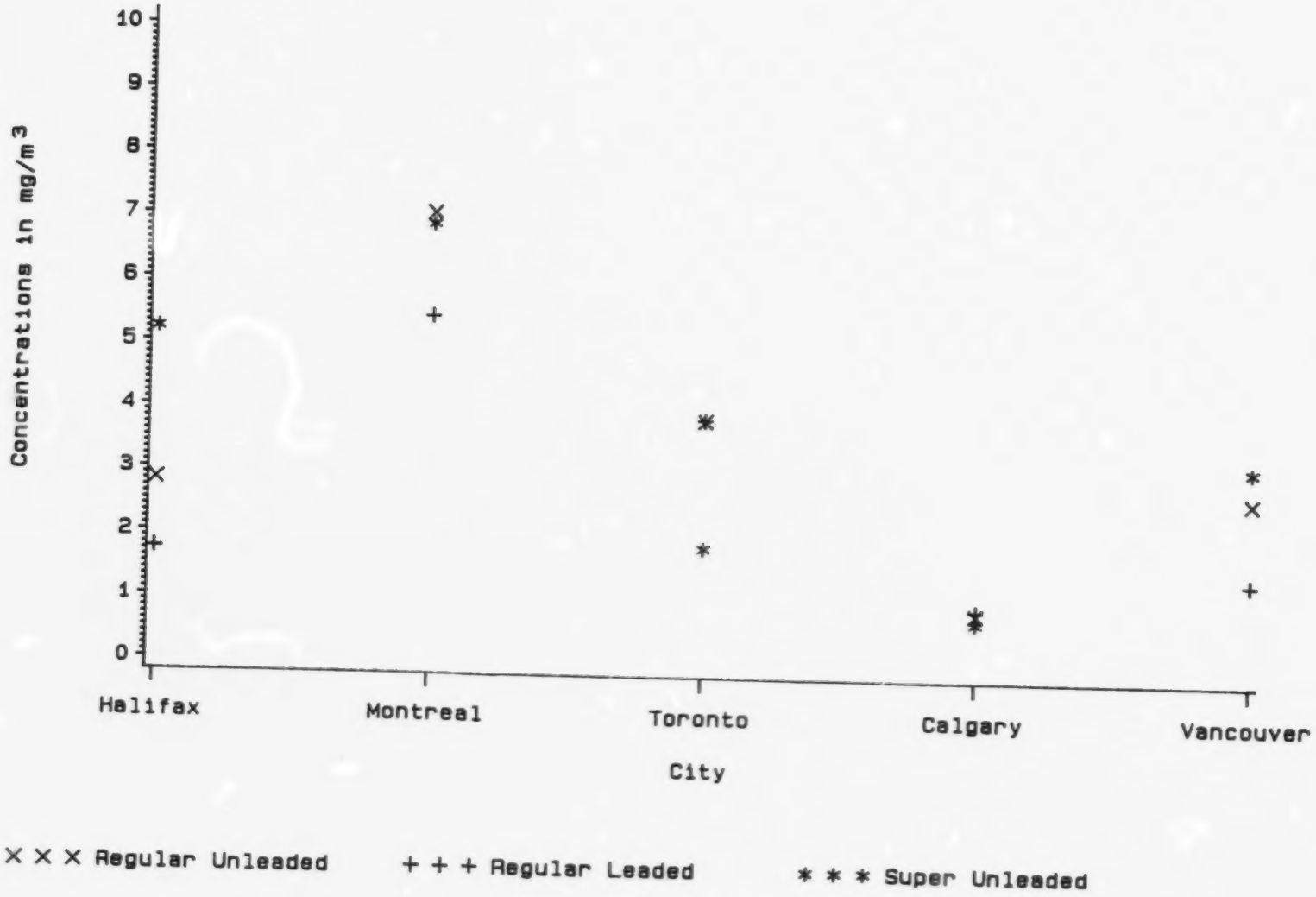


Fig. 14. Comparison of Mean Concentrations of Benzene by Cities for Area Samples

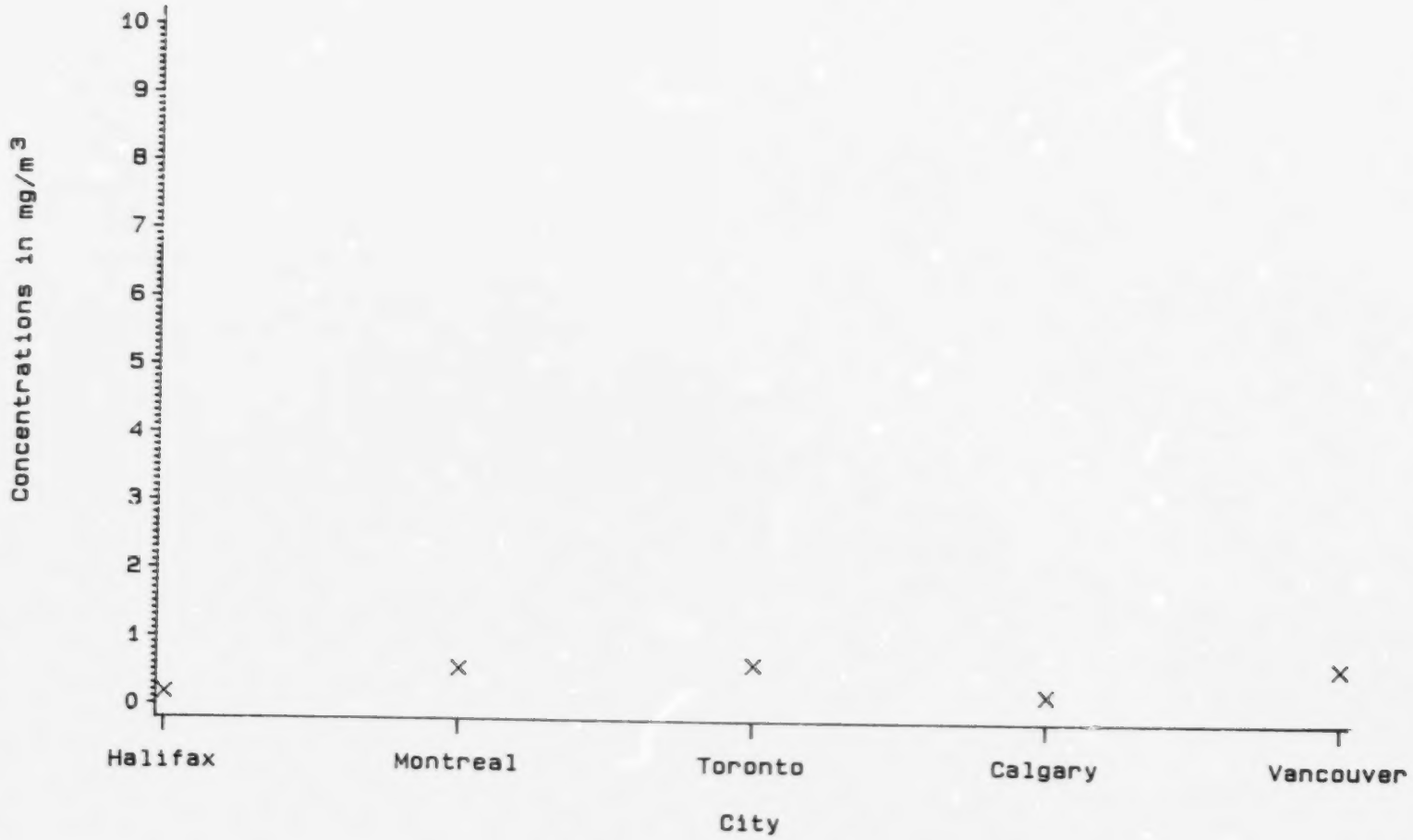


Fig. 15. Comparison of Mean Concentrations of Total Hydrocarbons by Cities for Long Term Personal Samples

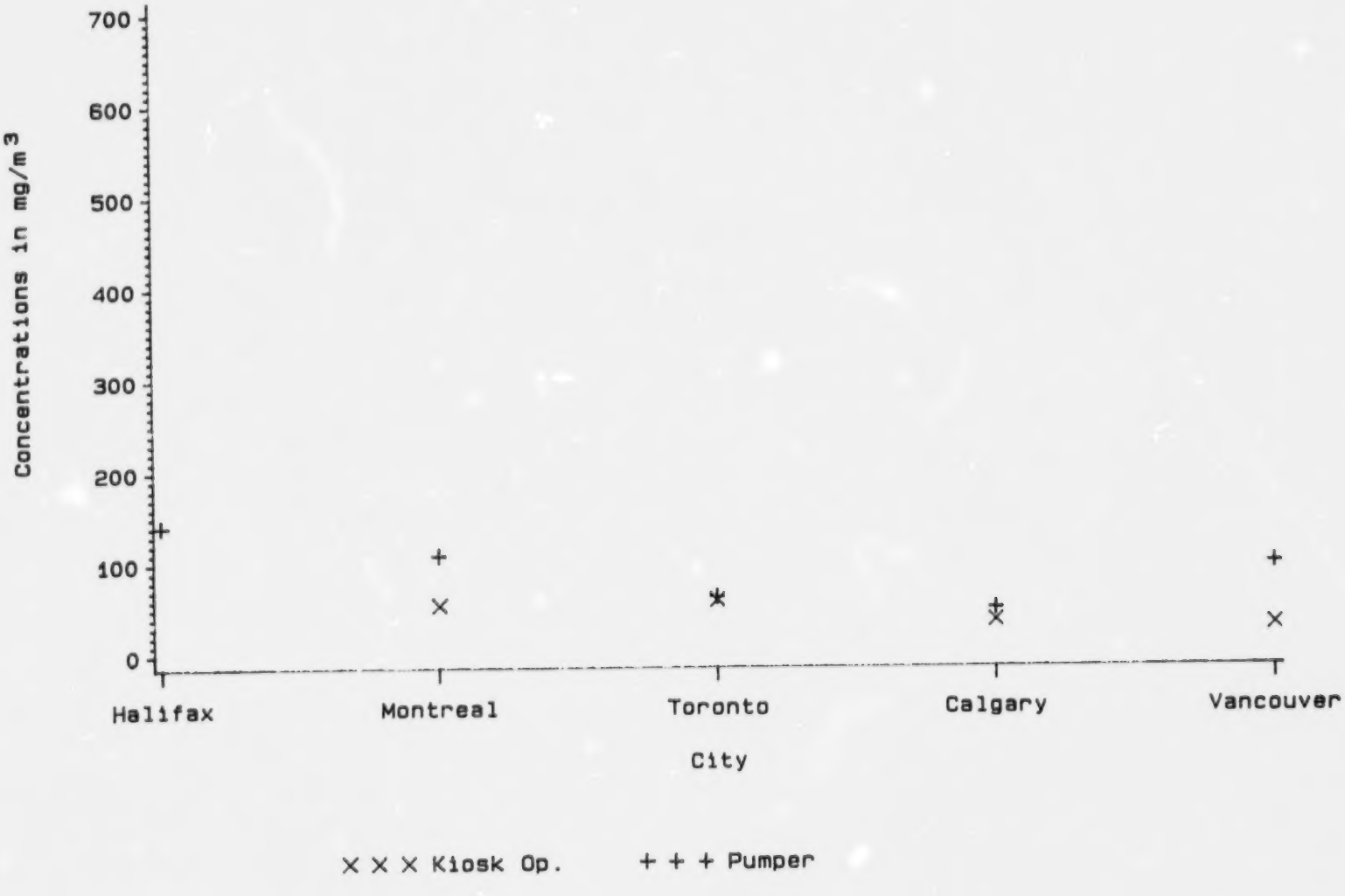


Fig. 16. Comparison of Mean Concentrations of Total Hydrocarbons by Cities for Short Term Personal Samples

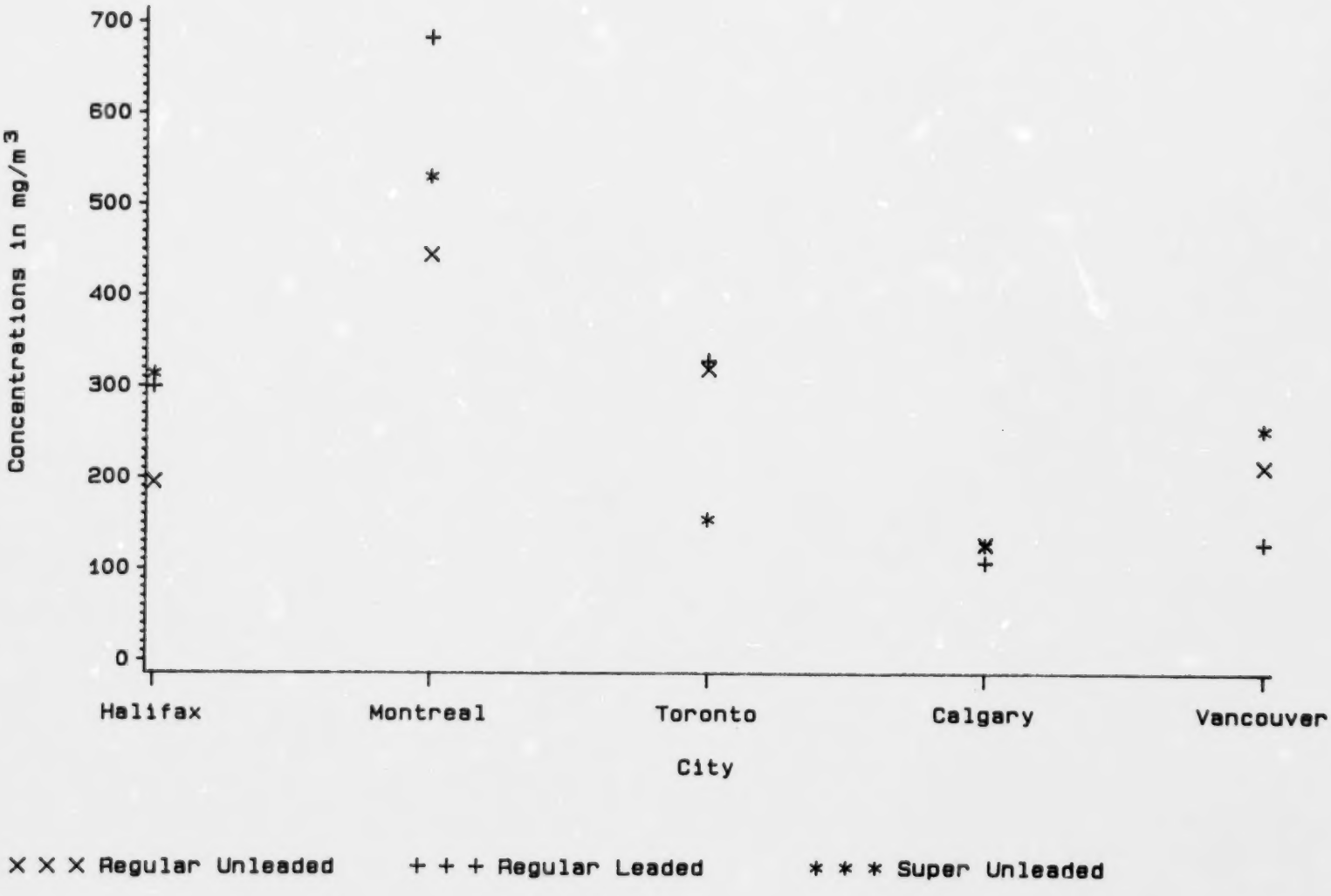


Fig. 17. Comparison of Mean Concentrations of Total Hydrocarbons by Cities for Area Samples

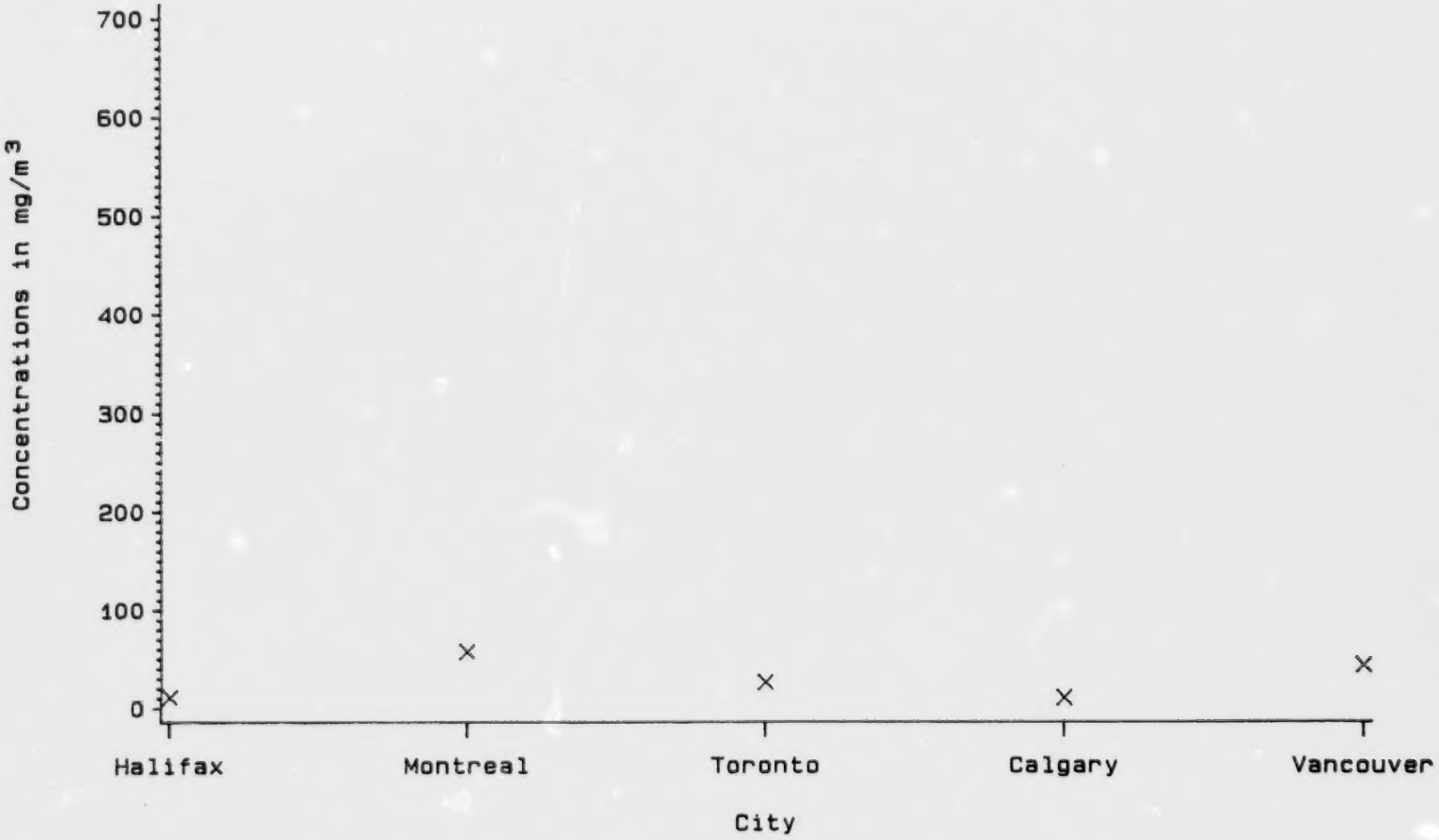


Fig. 18. Benzene Concentration Frequency Distribution for Long Term and Short Term Samples

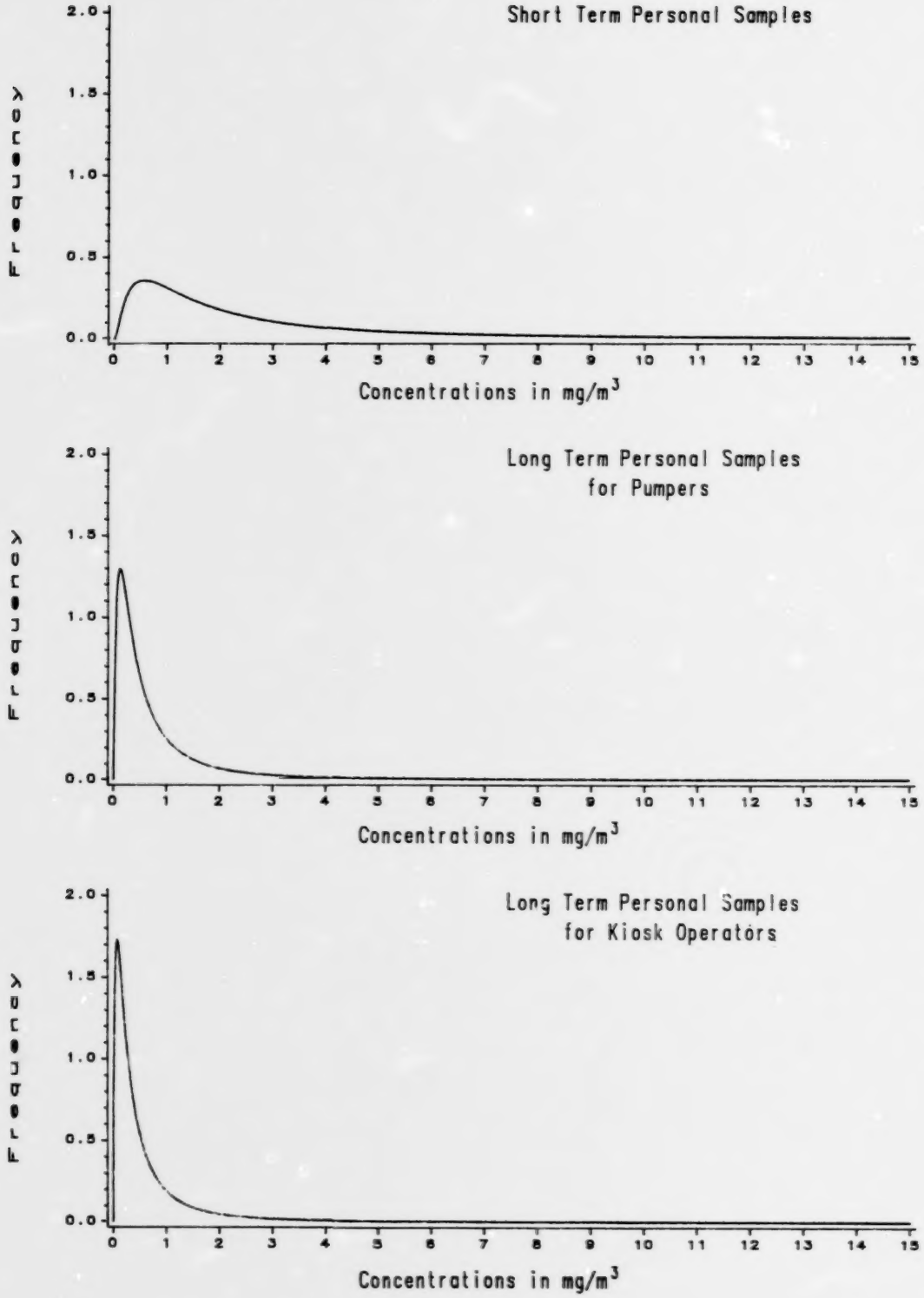


Fig. 19. Total Hydrocarbon Concentration Frequency Distribution for Long Term and Short Term Samples

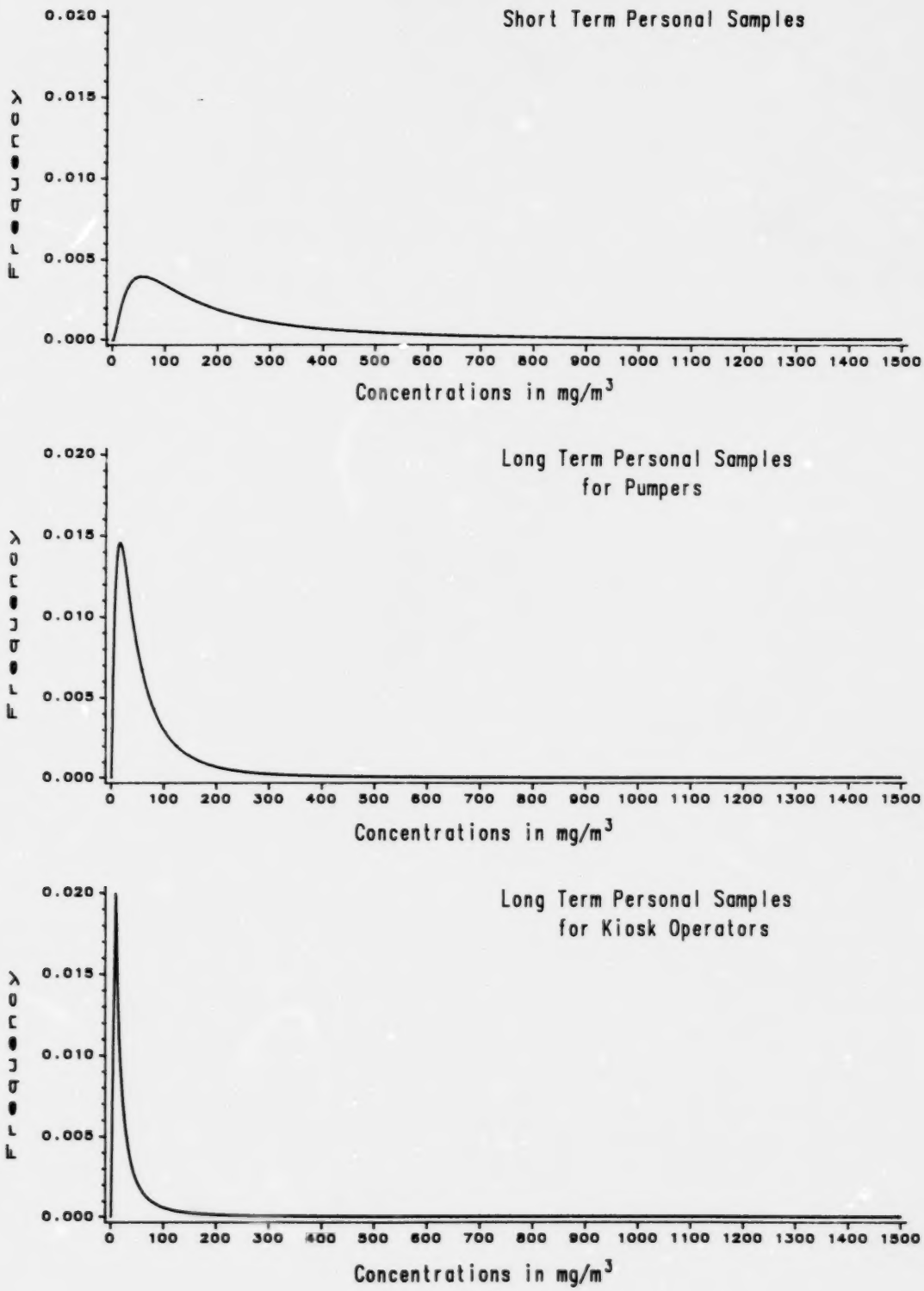


Fig. 20. Percent Composition of Bulk Gasoline and Airborne Samples by Hydrocarbon Groups for Regular Leaded Gasoline

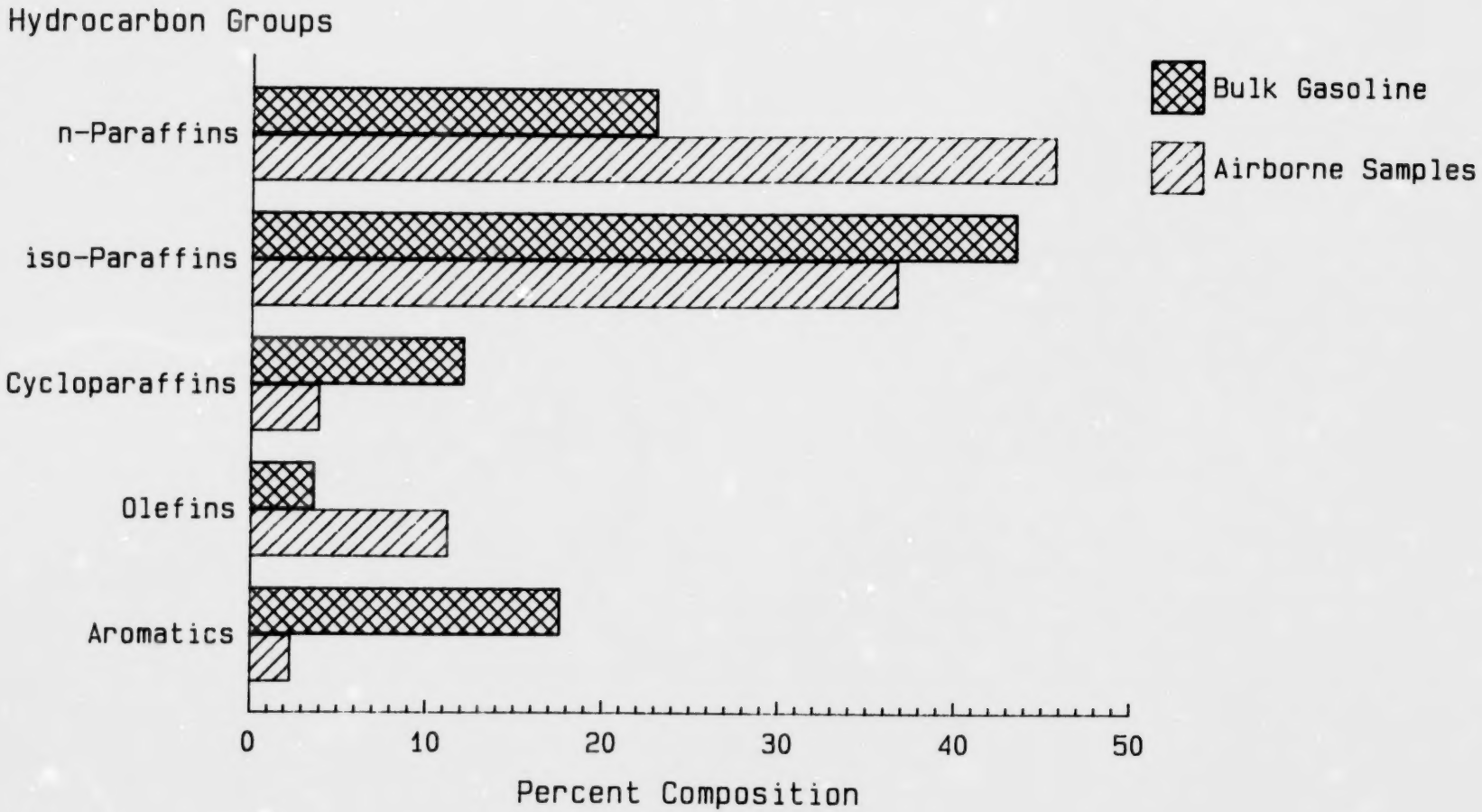


Fig. 21. Percent Composition of Bulk Gasoline and Airborne Samples by Hydrocarbon Groups for Regular Unleaded Gasoline

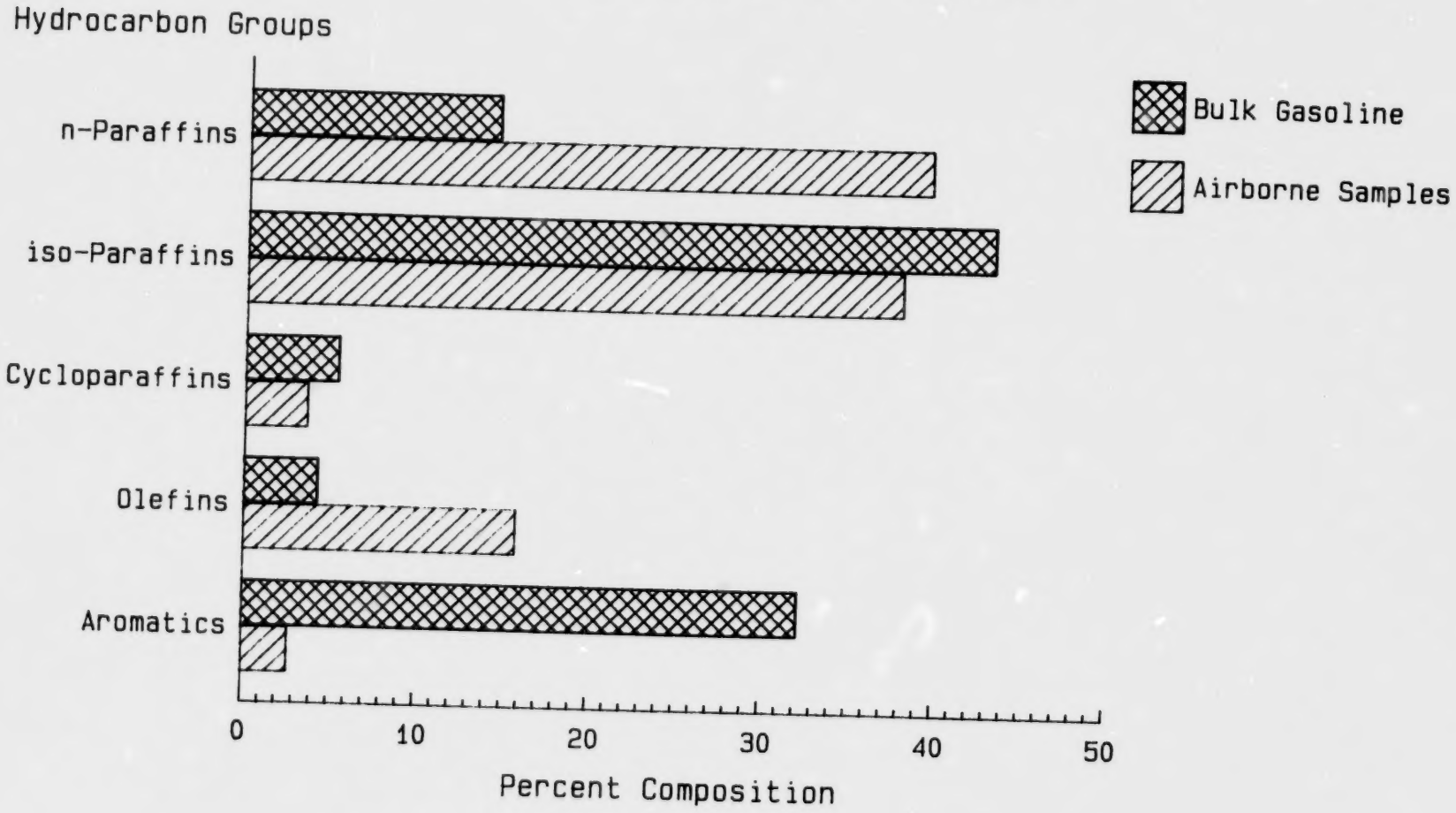


Fig. 22. Percent Composition of Bulk Gasoline and Airborne Samples by Hydrocarbon Groups for Super Unleaded Gasoline

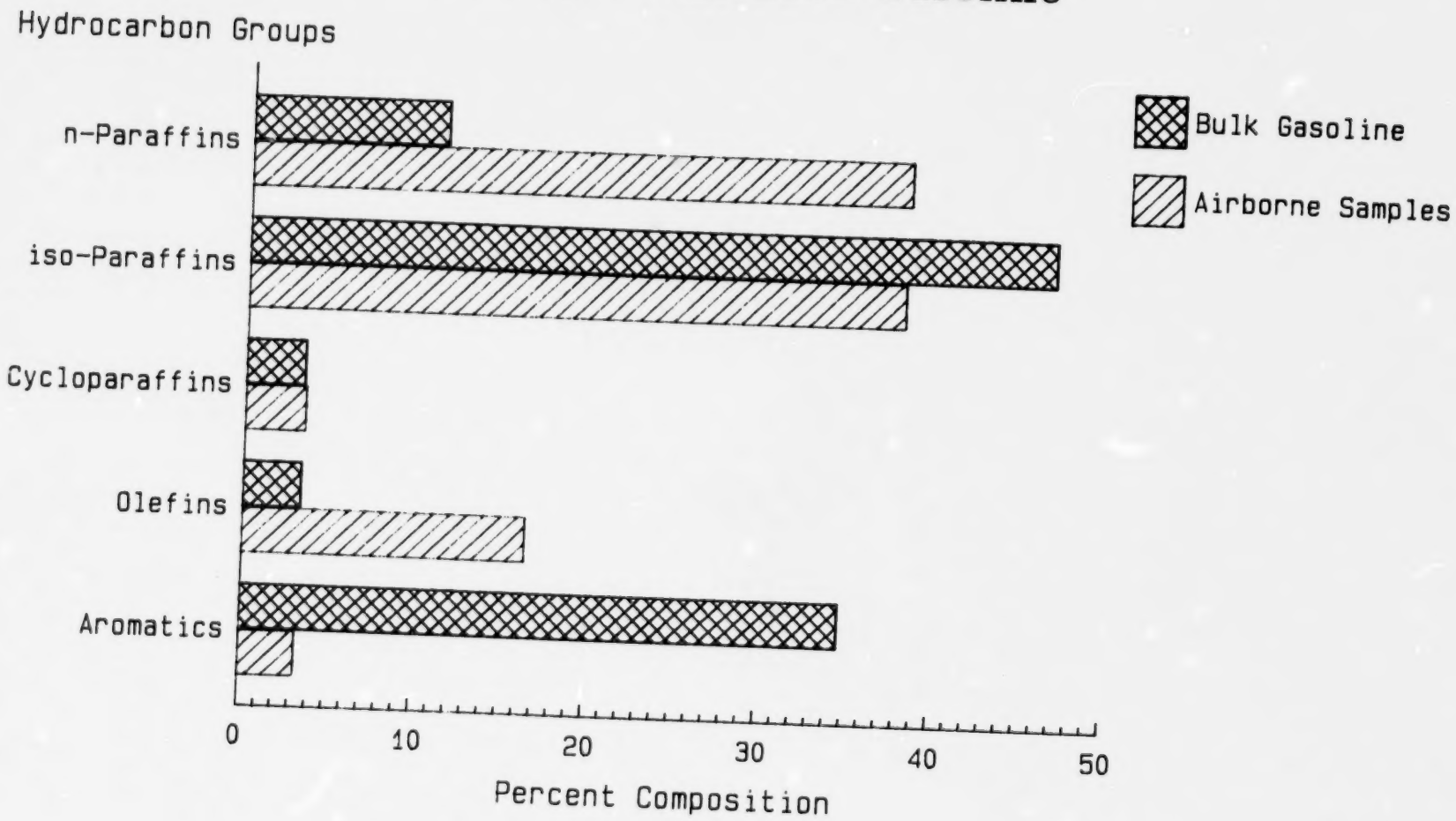


Fig. 23. Percent Composition of Bulk Gasoline and Airborne Samples by Components for Regular Leaded Gasoline

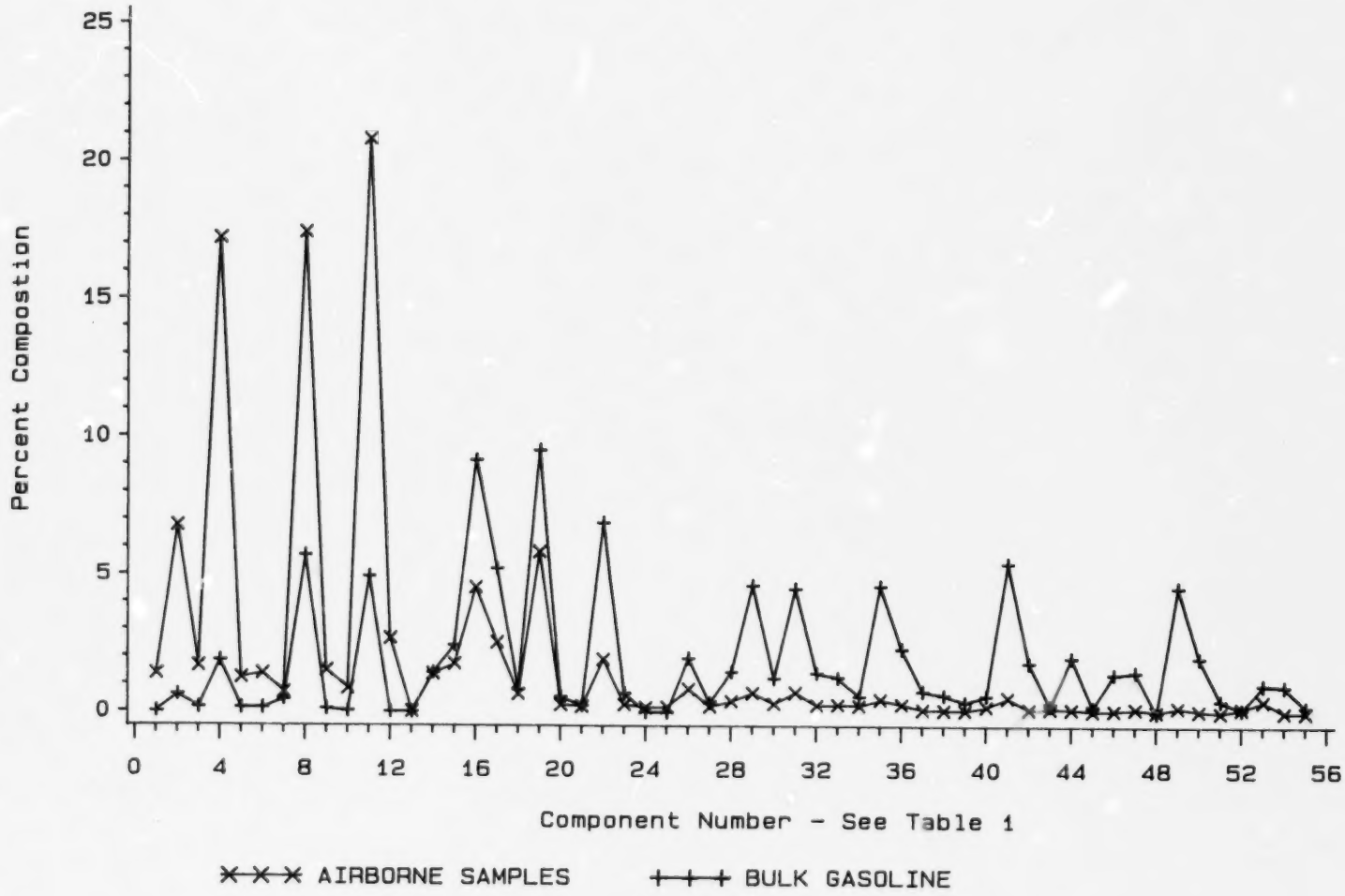


Fig. 24. Percent Composition of Bulk Gasoline and Airborne Samples by Components for Regular Unleaded Gasoline

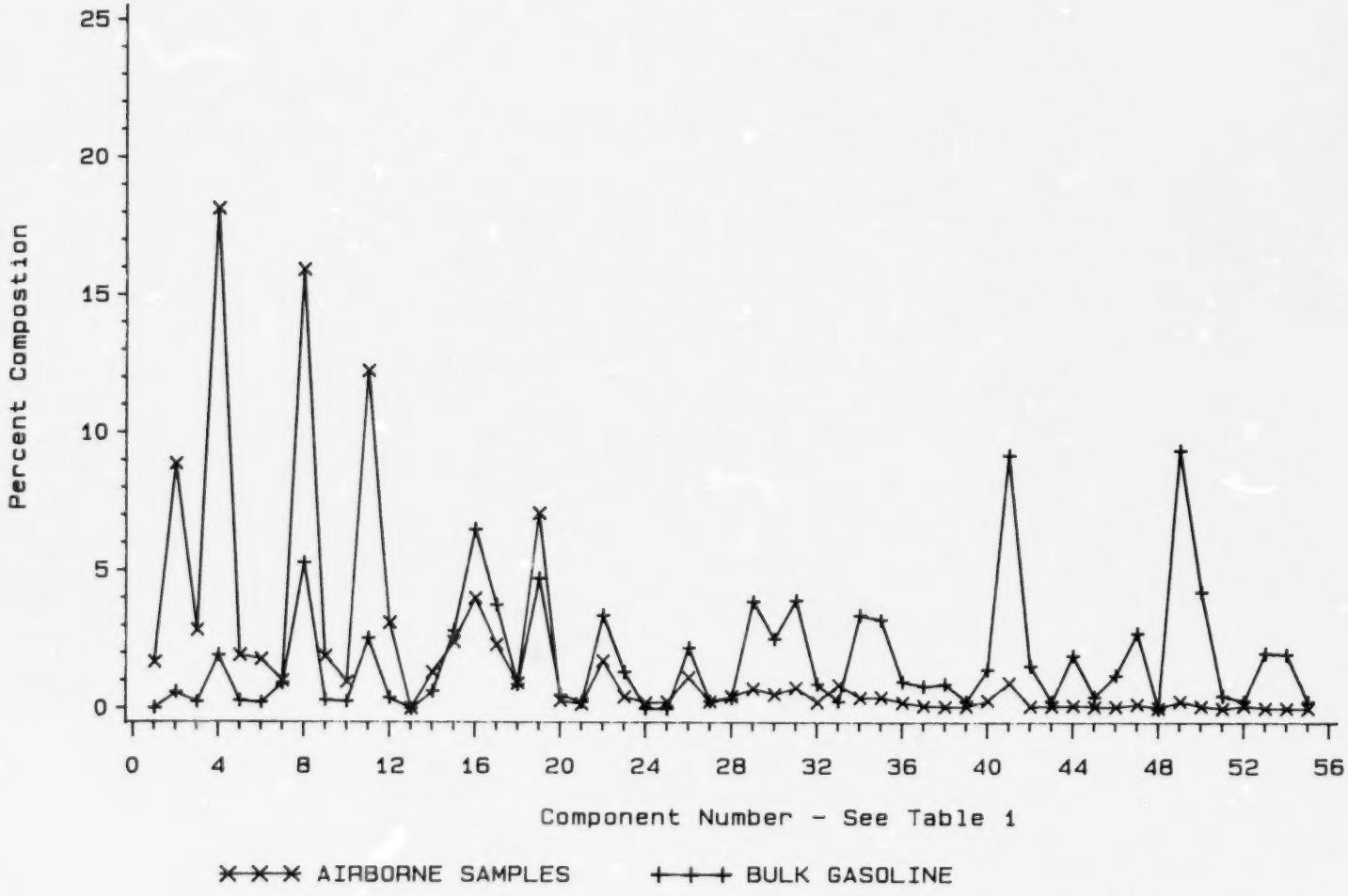


Fig. 25. Percent Composition of Bulk Gasoline and Airborne Samples by Components for Super Unleaded Gasoline

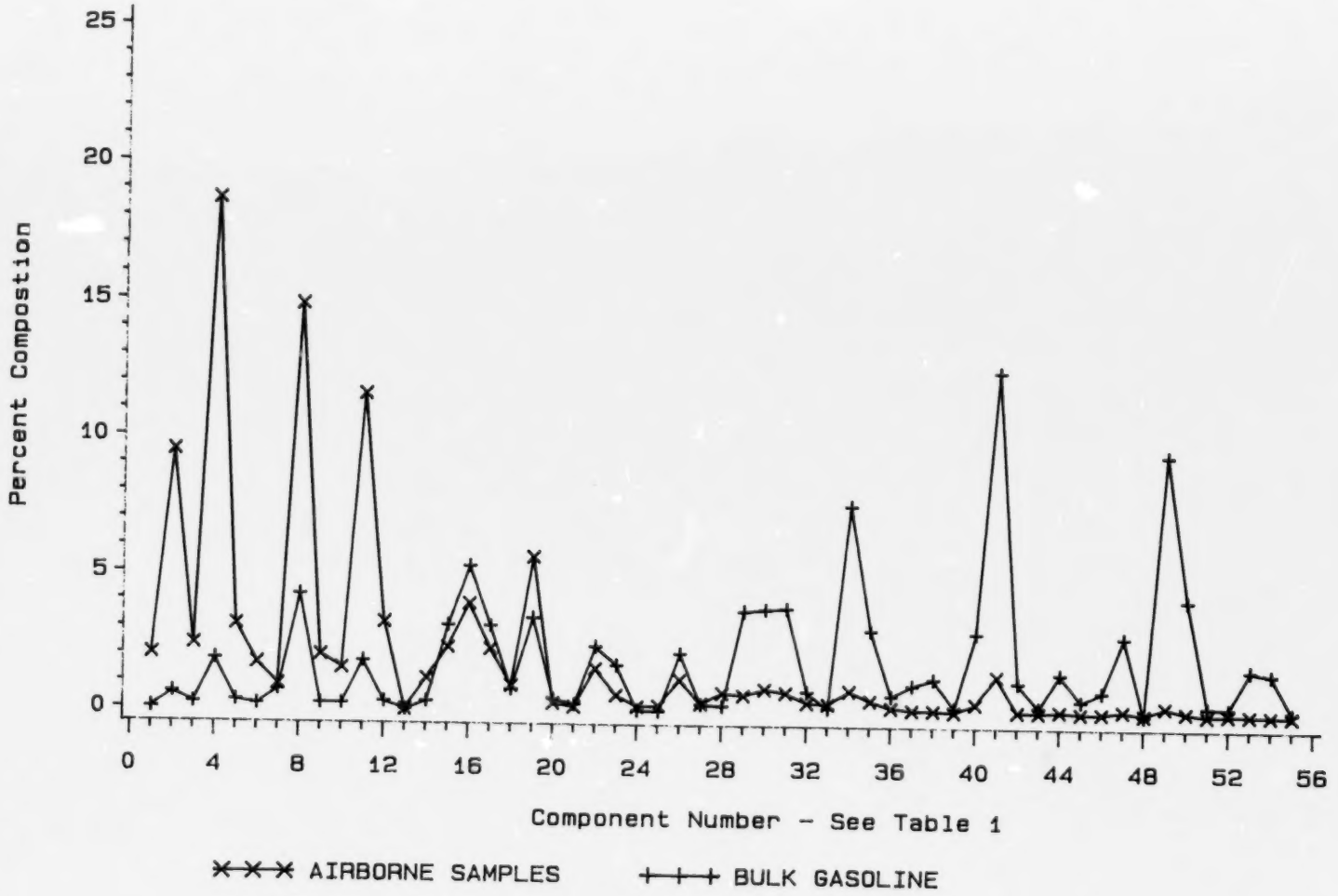
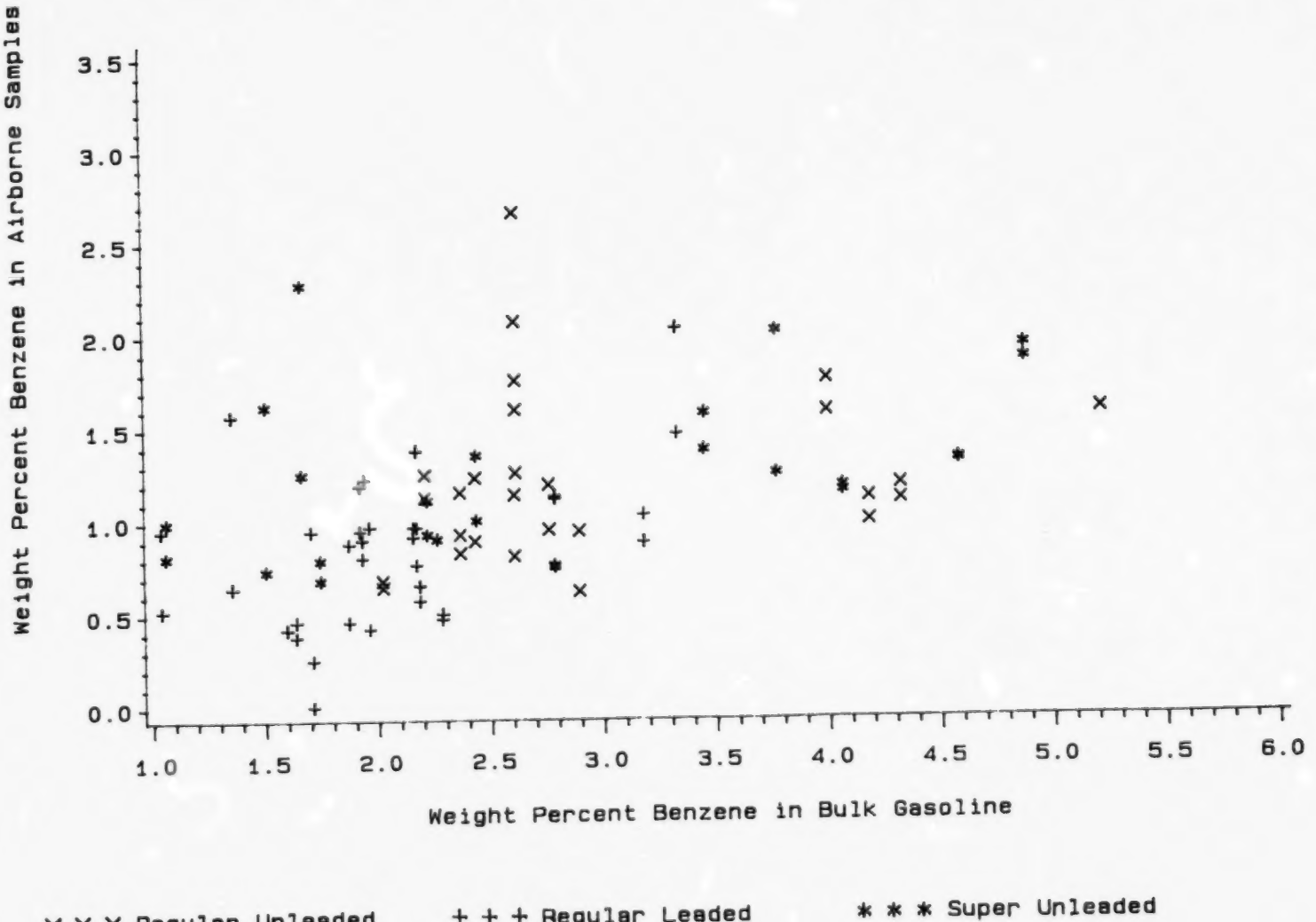


Fig. 26. Comparison of Percent Benzene in Airborne Samples to Percent Benzene in Bulk Gasoline



APPENDIX 1

AIR SAMPLING METHOD FOR STUDY OF EXPOSURE TO MOTOR GASOLINE HYDROCARBON VAPOURS

PRINCIPLE

Air possibly containing gasoline vapours is drawn at a specified flow rate for a known duration through an activated charcoal tube. The charcoal tube is analysed for various gasoline components by desorption with carbon disulfide and by capillary column gas chromatographic assay of the solvent extract.

AIR SAMPLING

1. Equipment

All equipment will be supplied by participating member Companies with the exception of charcoal tubes, sealing caps, and bulk sample bottles which will be provided through the study taskforce.

The sampling train used to obtain an air sample containing the gasoline vapours is to include the following components and satisfy the criteria suggested:

(a) A battery operated portable pump

- capable of delivering for 8 hours or full shift 50 cc/min. with a large charcoal tube (600 mg) in the sampling train, and up to 1000 cc/min. with a large charcoal tube for a period of 15 minutes.

- is intrinsically safe i.e. meets the National Electrical Code Class 1, Division 1, Group D as a minimum.

(b) A charcoal tube, large size (i.e. 400 mg front, 200 mg back). Identify by taping random number onto tube. Tape other copy of same number onto sampling sheet.

(c) A charcoal tube holder of appropriate size, which includes a clip for attachment to clothing, and an adapter for flexible tubing to ensure a leak proof fit.

(d) Tygon tubing of sufficient length with appropriate wall thickness to prevent collapsing when air is drawn through and with appropriate inner diameter which will provide a leak proof fit to the tube holder and to the inlet port of the portable pump.

In addition the following equipment will be required:

(a) a psychrometer for measuring ambient air temperature and relative humidity.

(b) an anemometer for wind speed and a compass to estimate wind direction.

(c) an ordinary thermometer to measure the bulk gasoline sample temperature.

(d) wide mouth glass sample bottles of approximately 125 ml in size with teflon lined lids for collecting bulk gasoline samples.

2. Sampling Procedures

(a) Before sampling:

- the pump battery pack must be fully charged, according to the manufacturer's instructions.

- the pump must be calibrated to the specified flow rate with the appropriate size charcoal tube in line using a primary standard e.g. a bubble meter, at the start and the end of each sampling day. (Note: pump must be allowed to run for at least 5 minutes before the first calibration.) For long-term samples, minimum of 7 hours, the flow rate will be 50 cc/minute using large (600 mg) size charcoal tube. For short-term samples, minimum 10 minutes and maximum 15 minutes the flowrate will be 1000 cc/minute using a large (600 mg) size charcoal tube.

Note: The established flow rate will be an average of three readings using the primary standard.

(b) Sampling:

- the samples to be taken are itemised in the enclosed table 'Sampling Plan'

Assemble the sampling train:

- break open charcoal tube (minimum 2mm opening);

- insert tube into holder (arrow on charcoal tube pointing towards the pump);

- attach one end of tubing to holder and other end to inlet port of pump;

- ensure tube is appropriately labelled.

- Attach the pump to the person and clip the tube holder in a verticle position as near as possible to the breathing zone. Ensure that the equipment will not interfere with the person's normal work activities.

- Switch on the pump, note the start time and/or start count.

  Note information as per 'sampling data sheet'.

- Each set of samples per city shall include one blank charcoal tube which is obtained from the same batch of charcoal tubes and is handled in the same manner as the sample tube (break, seal, transport) except that no air is drawn through them.

- If attendant leaves the site, remove the pump and turn it off before he leaves.

- During the sampling interval check the sampling train periodically to ensure that it is functioning properly.

- For short term samples the sampling pump is turned on when the gas tank is opened and turned off when gas tank cap replaced. Cap short term samples between individual fill ups. Record instances where attendant remained at pump for entire fill up.

- Record pertinent data (price war?, station throughput, etc.) on sampling data sheet.

(c) Bulk Samples

- A bulk sample of each type of gasoline should be taken according to the enclosed table 'Sample Plan'.

- Bottles should be suitably identified.

- The temperature of the bulk sample should be taken immediately using an immersion thermometer and recorded on the Bulk Sampling Data Sheet along with the other information listed on the sheet.

(d) Termination of Sampling

- Switch off the pump and record the stop time and/or end count.
- Remove the sampling train from the person.
- Remove the charcoal tube from the holder and cap both ends using the supplied caps.
- Immediately store the tubes in a refrigerator and leave in the fridge during the entire week of sampling.
- Recalibrate the sampling pump.
- Tubes must be shipped to the analytical lab in a refrigerated manner.
- Bulk samples must be shipped to the analytical lab in a separate container from the charcoal tubes.

(e) Environmental Data

- T, P, & RH can be obtained from local weather office. Ask for uncorrected BP levels. Measure wind speed at station.

(f) Area Samples

- Use working perimeter of station, maximum of 100 ft. from pumps.

Sample Plan for Phase II - Summer Study

The following samples should be taken at stations in each of the 5 selected cities:

Full Serve Stations	4	8-hour time-weighted average gas pump attendant
	4	8-hour time-weighted average environmental area samples at north, south, east and west property lines.
	6	short term (10-15 minute) exposure samples 2 during regular leaded gasoline fillups 2 during regular unleaded gasoline fillups 2 during super unleaded gasoline fillups
	1	blank
Self Serve Stations	3	8-hour time-weighted average - kiosk attendant
	4	8-hour time-weighted average environmental area samples at north, south, east and west property lines
	1	blank
Bulk Samples	1	regular leaded gasoline
	1	regular unleaded gasoline
	1	super unleaded gasoline

per city

PACE GASOLINE EXPOSURE STUDY
INDUSTRIAL HYGIENE SAMPLING DATA SHEET

SAMPLE NUMBER: _____

DUPLICATE OF: _____

DATE (Yr/Mth/day): _____

1. LOCATION: ☐ Hfx. ☐ Mtl. ☐ Tor. ☐ Cgy. ☐ Vcr.
2. TYPE OF OPERATION: ☐ Full Serve ☐ Self-Serve
3. JOB FUNCTION TITLE: ☐ Pumper ☐ Kiosk Operator
4. JOB ACTIVITY: ☐ Pumping Gas ☐ Tank Dip ☐ Fuel Sample
   ☐ Attending Kiosk ☐ Mechanical Work ☐ Windshield
   ☐ Spill Clean-Up
5. TYPE OF SAMPLE:
   ☐ Long Term ☐ Short Term ☐ Area ☐ Bulk
   ☐ Reg Pb ☐ North
   ☐ Reg ☐ South
   ☐ Super ☐ East
   ☐ West
6. RELATIVE HUMIDITY: _____ %
7. AVERAGE TEMPERATURE: _____ °C
8. BAROMETRIC PRESSURE: _____ KPa
9. WIND SPEED (ft/sec): ☐ a.m. ☐ p.m. ☐ mid-day
10. WIND DIRECTION(from): ☐ a.m. ☐ p.m. ☐ mid-day
11. WORKER TO SOURCE: ☐ Upwind ☐ Downwind ☐ Variable
12. KIOSK LOCATION: ☐ Centre ☐ Side _____ Distance (m)
13. SMOKING: ☐ Yes ☐ No
14. OTHER MATERIALS (check only if filled): ☐ Propane
    ☐ Diesel ☐ Gasohol
15. SERVICE STATION TOTAL THROUGHPUT (litres) _____

Flow Rate Start	End	Avg. Flow Rate

Start Count	End	Total Net Count

Start Vol/Stroke	End	Avg. Vol/Stroke

START TIME _____ STOP TIME _____ TOTAL TIME _____

TOTAL VOLUME OF AIR SAMPLES (Litres): _____

COMMENTS, WORK TASK DETAILS
REMARKS, DIAGRAM, ETC.

SAMPLE MEDIA: 600 mg Charcoal Tube

CALIBRATION METHOD: Bubble Meter

SAMPLING EQUIP.: _____

PUMP NO. (not serial) _____

STEL: 1 litre/minute

TWA: 50 cc/minute

APPENDIX 2

ANALYTICAL METHOD FOR STUDY OF EXPOSURE TO MOTOR GASOLINE HYDROCARBON VAPOURS

1. When the samples were received at the laboratory, they were logged. The tubes were then broken open, the charcoal separated - front and back, into two 1 dram vials and stored in a freezer at -20°C.

2. Apparatus

   (a) Hewlett Packard 5890 with a 3392A Integrator gas chromatograph, autosampler, capillary column and flame ionization detector.

   (b) Column: SPB-1 bonded phase, thick film (1.0μm), nonpolar, methyl silicone, fused silica WCOT capillary column (60m x .32mm ID).

   (c) Desorbing vials, 1 dram.

   (d) Ultrasonic bath.

   (e) Autosampler vials, 1.5 mL with screw caps and septums.

   (f) Syringes of convenient sizes for making standards.

   (g) Pipets, 1.0 mL increments.

   (h) Volumetric flasks of convenient sizes for making standards.

3. Reagents

   (a) Spectroquality carbon disulfide.

   (b) Samples of specific hydrocarbons under study, chromatoquality grade, for use as standards.

   (c) High purity helium.

   (d) High purity hydrogen.

   (e) High purity compressed air.

4. Analysis of Samples

(a) Desorption of samples. Just before analysis, 2 mL of carbon disulfide were pipetted into the vials containing the charcoal from the samples. The samples are shaken with a horizontal shaker for at least 30 minutes before analysis.

(b) GC conditions. The typical operating conditions for the gas chromatograph were:
(i) 0.6 cc/min. with approximately 30 cc/min. make-up helium carrier gas flow.
(ii) 25.8 cc/min. hydrogen flow.
(iii) 272.7 cc/min. air flow.
(iv) 200°C injection port temperature.
(v) 275°C detector temperature.
(vi) oven temperature program:
32°C for 8 minutes
180°C at 6°C/min. and held for 5 min.

(c) Each front section was injected twice and each back section was injected once. Approximately 1.4 mL was injected.

(d) McMaster found that the analytical method was able to resolve the components of interest with careful sample injection into the gas chromatograph with two exceptions:
(1) 2-methyl-2-butene could not be resolved from the carbon disulfide peak and therefore was reported as 0.
(2) Methylcyclohexane and 2,2-dimethylhexane could not be resolved separately and so were reported together as methylcyclohexane.

5. Determination of Desorption Efficiencies

Charcoal tubes from the same lot were scored and opened at the front. The front section was emptied into a 1 dram. vial. 2mL of a prepared standard was pipetted onto the charcoal. The charcoal was allowed to stand overnight to come to equilibrium. At least three (3) vials were prepared in this manner. These samples in the vials as well as blanks were analyzed in the same manner as the regular samples.

$$\text{Desorption efficiency} = \frac{\text{Sample Concentration - Blank Concentration}}{\text{Concentration of Standard}}$$

This was done for all 55 components. Table 1 lists the desorption efficiencies used for the 55 components.

6. Calibrations and Standards

For the following components, standards are prepared by injecting approximately 20 ul of each hydrocarbon into a 10 mL septum screw cap volumetric flask and weighing on the semi-micro balance to calculate the exact weight. The flask is filled to the mark with methanol. Standards for calibrating the G.C. are made by injecting 1.0 ul of the stock solutions into 1 mL of carbon disulfide.

cyclopentane
2,3-dimethylbutane
trans-3-methyl-2-pentane
2,2-dimethylpentane
methylcyclopentane
2,4-dimethylpentane
2,2,3-trimethylbutane
cis 4,4-dimethylpentane
benzene
3,3-dimethylpentane
methylcyclohexane
2,5-dimethylhexane
2,4-dimethylhexane
3,3-dimethylhexane
2,3,4-trimethylpentane
toluene
2-methylheptane
isopropylbenzene
ethyl toluene
1,3,5-trimethylbenzene
1-hexene
n-hexane
2-methylpentane
3-methylpentane
cyclohexane
2-methylhexane
2,3-dimethylpentane
3-methylhexane
3-ethylpentane
1-heptane
2,2,4-trimethylpentane
n-heptane
3,4-dimethylhexane
3-methylheptane
2,2,5-trimethylhexane
n-octane
ethyl benzene
m-xylene
p-xylene
o-xylene
n-nonane
n-decane

For the following components standards are made by injecting 10 ul into 5 mLs of hexane, followed by weighing on semi-micro balance to calculate the exact weight. Standards to calibrate the G.C. are made by diluting 5 ul in 1 ml of carbon disulfide.

3-methyl-1-butene
isopentane
1-pentene
2-methyl-1-butene
n-pentane
trans-2-pentene

(note: 2-methyl-2-butene does not separate from the carbon disulfide peak)

Standards for gases are made by injecting 1 mL of each gas with a gas-tight syringe into 5 mL of hexane, followed by weighing on semi-micro balance to calculate the exact weigh Standards to calibrate the G.C. are made by diluting 10 µl into 1 mL of carbon disulfide.

propane	n-butane
isobutane	trans-2-butene
1-butene	cis-2-butene

Each calibration standard should be made up at least four times. The standards should agree to within 5% of each other. The G.C. is calibrated with all 54 components prior to analysing a set of charcoal tube samples.

7. Calculation of Total Hydrocarbons

Concentrations of total hydrocarbons were calculated as the sum of the 55 individual components reported for a particular sample.

Table 1: Desorption Efficiencies by Component

COMPONENT NO.	COMPOUND	DESORPTION EFFICIENCY
1	Propane	1.000
2	Isobutane	1.000
3	1-Butene	1.000
4	n-Butane	1.000
5	Trans-2-butene	1.000
6	Cis-2-butene	1.000
7	3-Methyl-1-butene	1.000
8	Isopentane	1.000
9	1-Pentene	1.000
10	2-Methyl-1-butene	1.000
11	n-Pentane	1.000
12	Trans-2-pentene	1.000
13	2-Methyl-2-butene	
14	Cyclopentane	1.000
15	2,3-Dimethylbutane	1.000
16	2-Methylpentane	1.000
17	3-Methylpentane	1.000
18	1-Hexene	1.000
19	n-Hexane	1.000
20	Trans-3-methyl-2-pentene	1.000
21	2,2-Dimethylpentane	0.963
22	Methylcyclopentane	1.000
23	2,4-Dimethylpentane	1.000
24	2,2,3-Trimethylbutane	0.981
25	Cis-4,4-Dimethylpentene	1.000
26	Benzene	0.930
27	3,3-Dimethylpentane	1.000
28	Cyclohexane	0.770
29	2-Methylhexane	1.000
30	2,3-Dimethylpentane	1.000
31	3-Methylhexane	0.971
32	3-Ethylpentane	1.000
33	1-Heptene	0.966
34	2,2,4-Trimethylpentane	0.933
35	n-Heptane	0.952
36	Methylcyclohexane and 2,2-Dimethylhexane	1.000
37	2,5-Dimethylhexane	0.960
38	2,4-Dimethylhexane	0.965
39	3,3-Dimethylhexane	1.000
40	2,3,4-Trimethylpentane	1.000
41	Toluene	0.823
42	2-Methylheptane	0.945
43	3,4-Dimethylhexane	0.945
44	3-Methylheptane	1.000
45	2,2,5-Trimethylhexane	0.950
46	n-Octane	0.948
47	Ethylbenzene	0.916
48	m-Xylene	0.885
49	p-Xylene	0.853
50	o-Xylene	0.798
51	n-Nonane	1.000
52	Isopropylbenzene	0.964
53	Ethyltoluene	1.000
54	1,3,5-Trimethylbenzene	0.912
55	n-Decane	1.000

APPENDIX 3

MEAN AIRBORNE CONCENTRATIONS BY CARBON NUMBERS AND BY HYDROCARBON GROUPS

Figures

A3-1 Mean Airborne Concentrations by Carbon Numbers for Long Term Personal Samples

A3-2 Mean Airborne Concentrations by Carbon Numbers for Short Term Personal Samples

A3-3 Mean Airborne Concentrations by Carbon Numbers for Area Samples

A3-4 Mean Airborne Concentrations by Hydrocarbon Groups for Long Term Personal Samples

A3-5 Mean Airborne Concentrations by Hydrocarbon Groups for Short Term Personal Samples

A3-6 Mean Airborne Concentrations by Hydrocarbon Groups for Area Samples

Fig. A3–1. Mean Airborne Concentrations by Carbon Numbers for Long Term Personal Samples

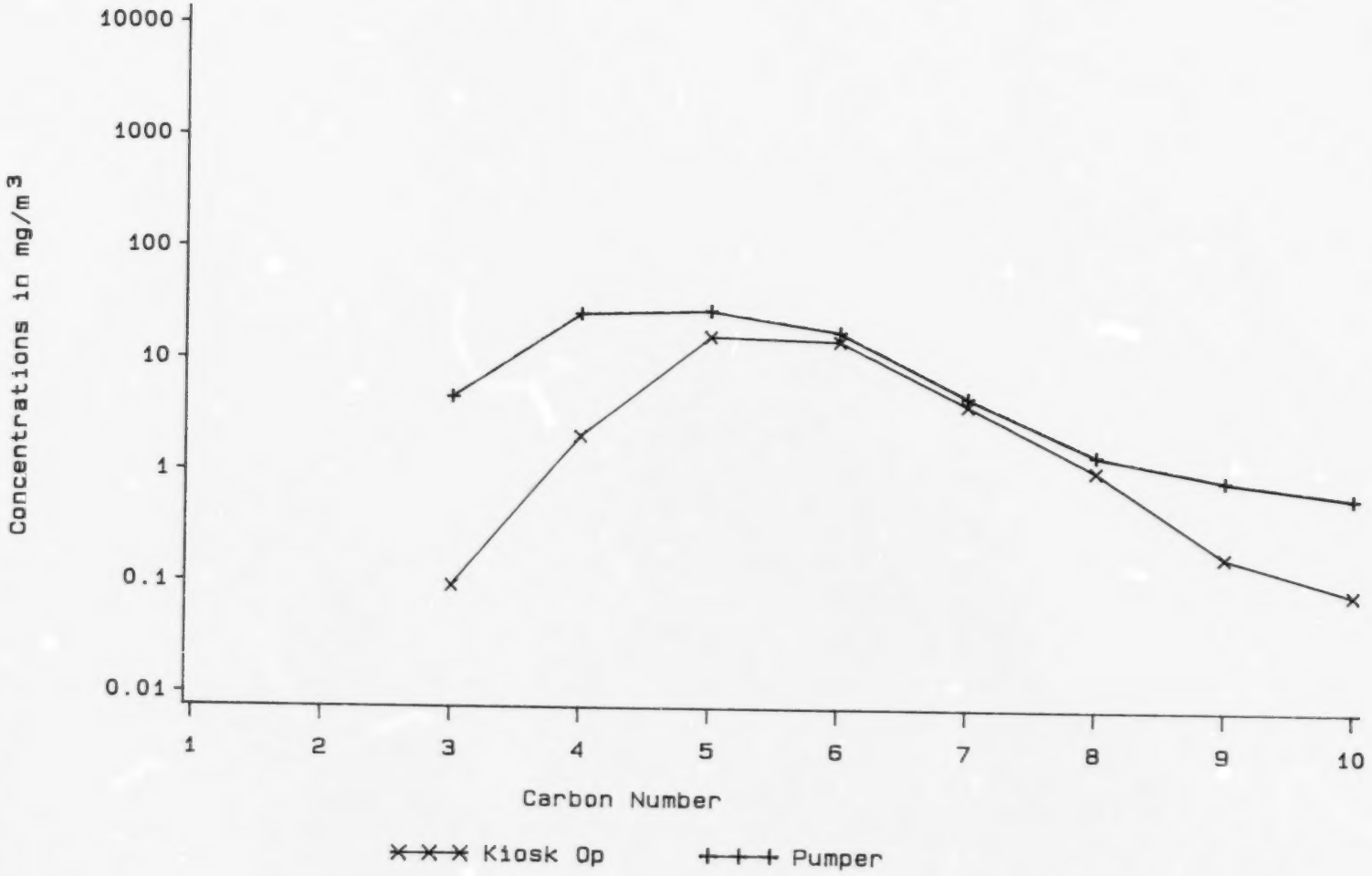


Fig. A3–2. Mean Airborne Concentrations by Carbon Numbers for Short Term Personal Samples

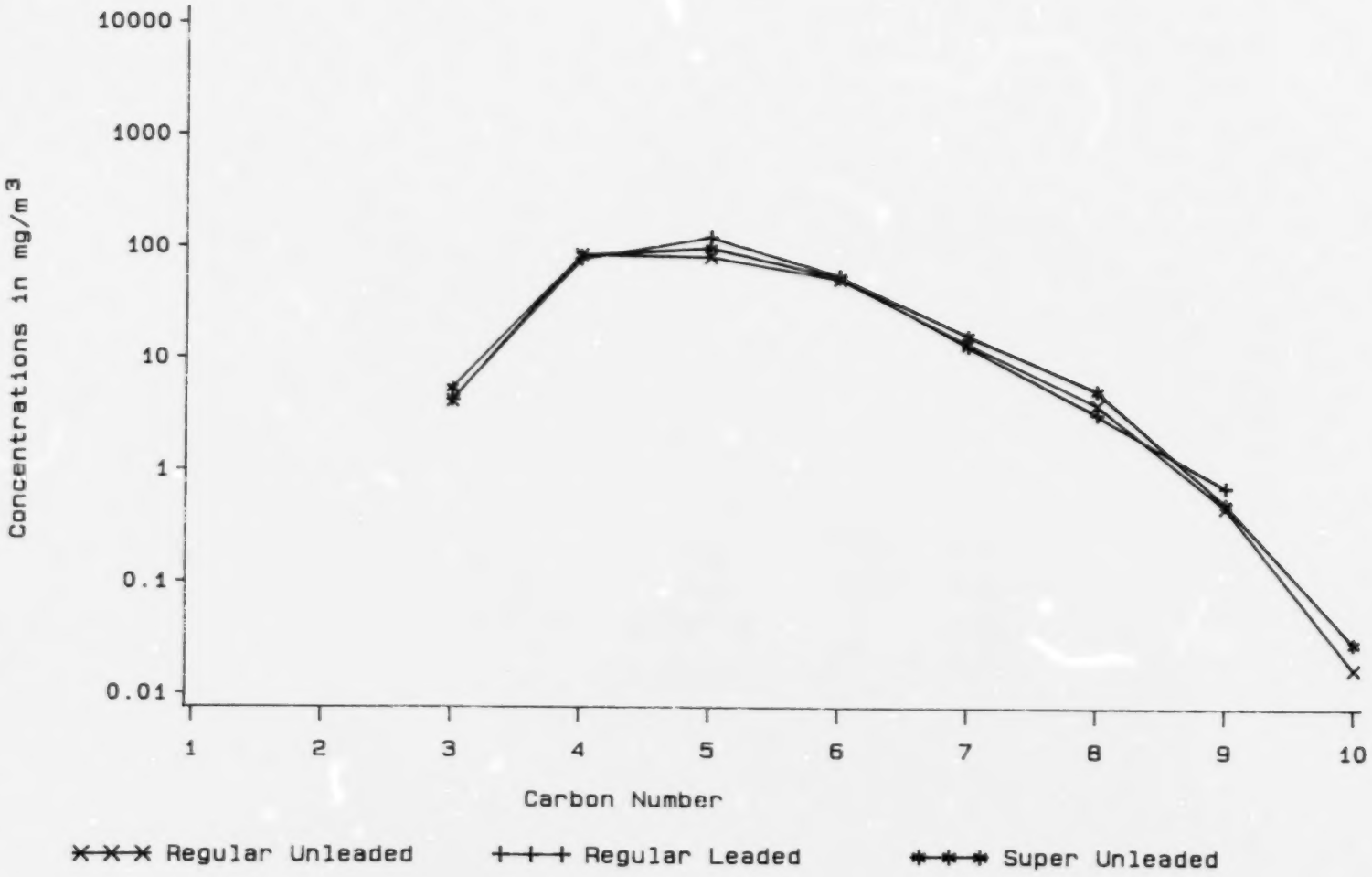


Fig. A3–3. Mean Airborne Concentrations by Carbon Numbers for Area Samples

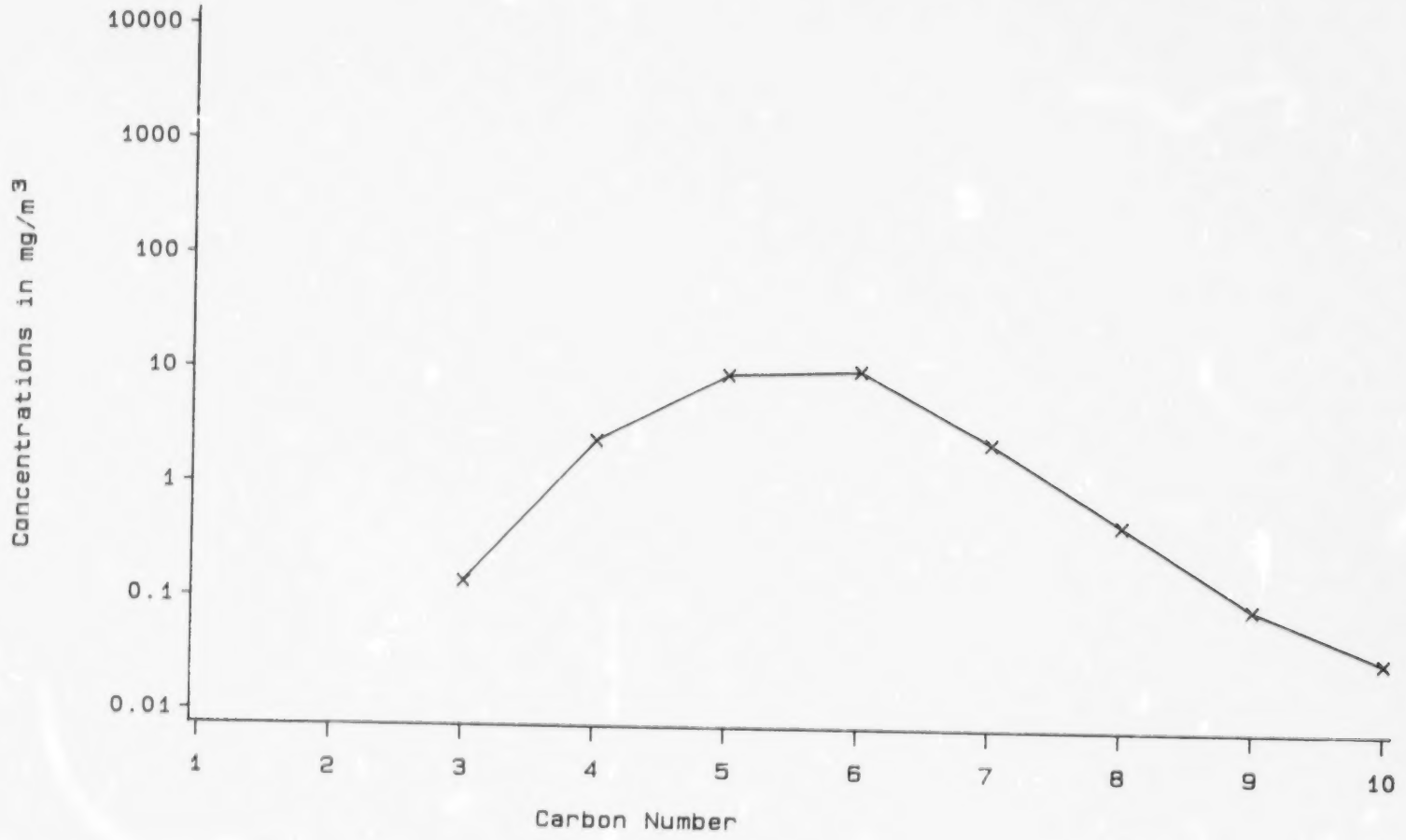


Fig. A3–4. Mean Airborne Concentrations by Hydrocarbon Groups for Long Term Personal Samples

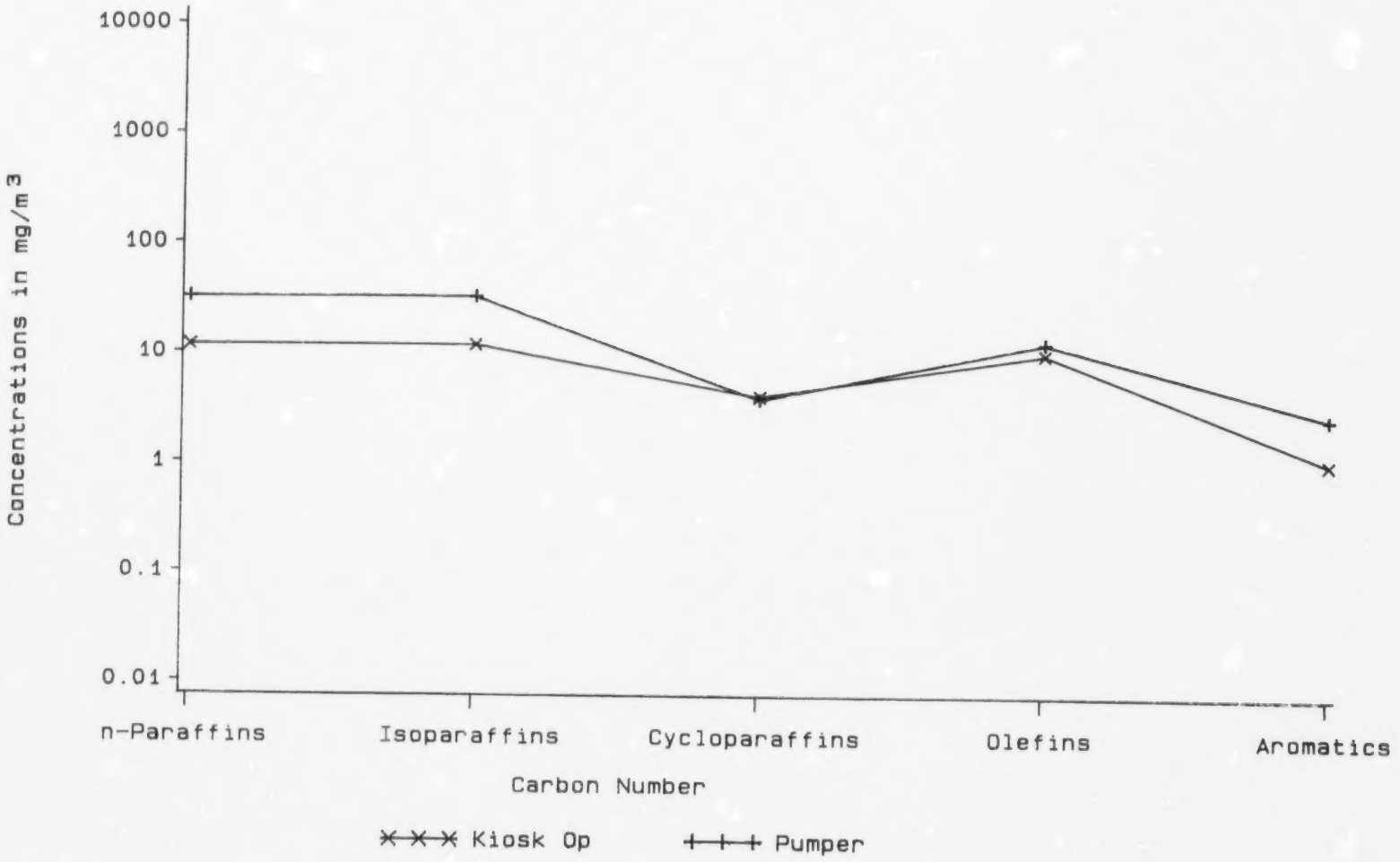


Fig. A3–5. Mean Airborne Concentrations by Hydrocarbon Groups for Short Term Personal Samples

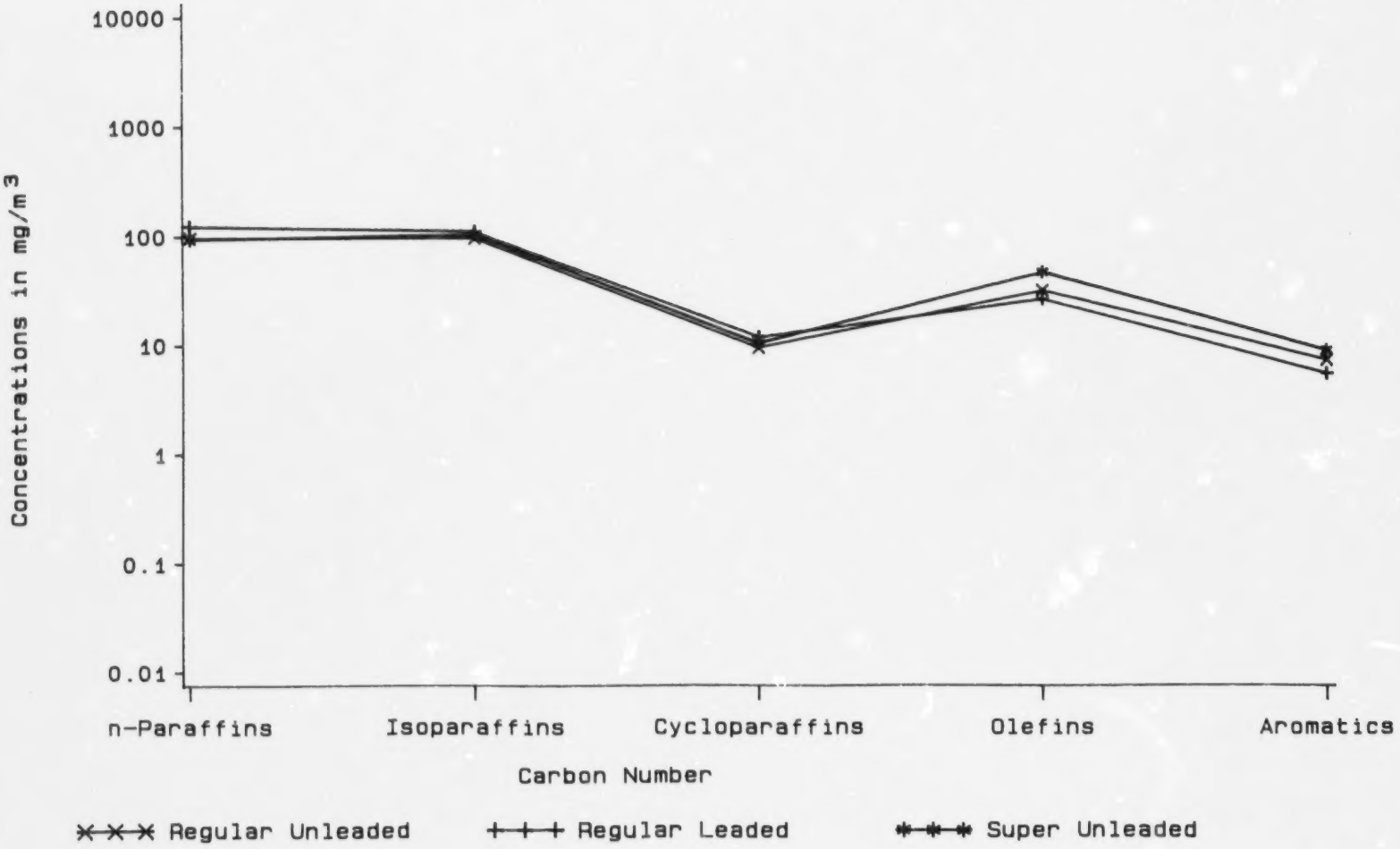
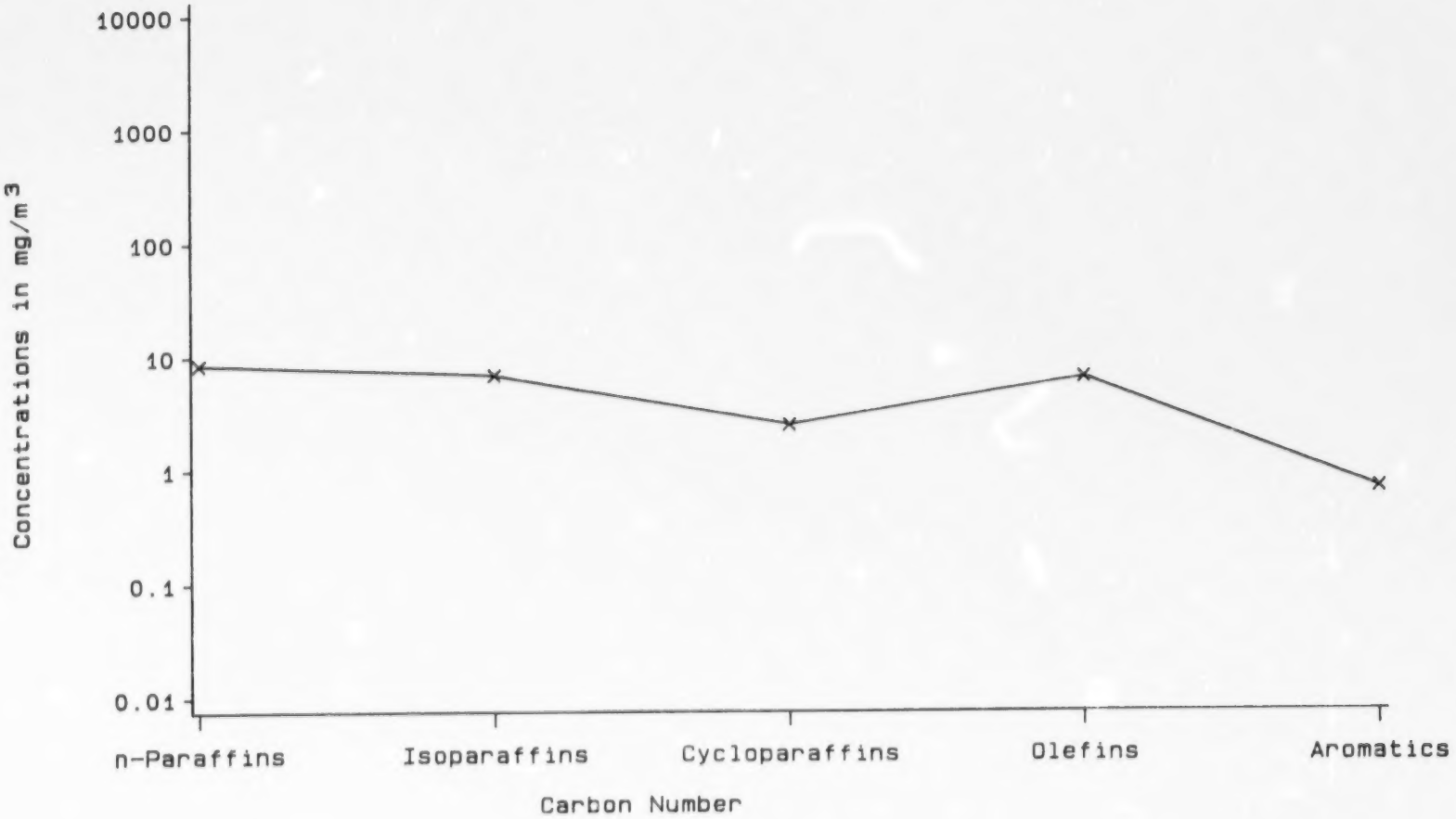


Fig. A3–6. Mean Airborne Concentrations by Hydrocarbon Groups for Area Samples



APPENDIX 4

DETAILED DESCRIPTIVE STATISTICS OF SAMPLE RESULTS

Tables

A4-1 Descriptive Statistics of Long Term Personal Samples for Kiosk Operators

A4-2 Descriptive Statistics of Long Term Personal Samples for Pumpers

A4-3 Descriptive Statistics of All Short Term Personal Samples

A4-4 Descriptive Statistics of Short Term Personal Samples for Regular Leaded Gasoline

A4-5 Descriptive Statistics of Short Term Personal Samples for Regular Unleaded Gasoline

A4-6 Descriptive Statistics of Short Term Personal Samples for Super Unleaded Gasoline

A4-7 Descriptive Statistics of All Area Samples.

TABLE A4-1. DESCRIPTIVE STATISTICS OF LONG TERM PERSONAL SAMPLES FOR KIOSK OPERATORS (NO. OF SAMPLES=50)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	0.131	0.168	0.000	0.029	0.084	0.168	0.342	1.071	1.071
Isobutane	0.676	1.879	0.000	0.034	0.166	0.592	2.285	12.976	12.976
1-Butene	0.105	0.282	0.000	0.013	0.040	0.087	0.257	1.950	1.950
n-Butane	1.298	3.818	0.000	0.084	0.263	1.221	3.081	26.795	26.795
Trans-2-butene	0.039	0.093	0.000	0.000	0.000	0.000	0.256	0.434	0.434
Cis-2-butene	0.049	0.077	0.000	0.000	0.019	0.057	0.241	0.403	0.403
3-Methyl-1-butene	1.448	3.467	0.000	0.000	0.172	1.419	8.178	20 304	20.304
Isopentane	2.655	4.414	0.000	0.324	0.942	2.426	13.062	21.829	21.829
1-Pentene	2.550	4.952	0.000	0.000	0.377	2.715	12.617	21.349	21.349
2-Methyl-1-butene	1.452	2.933	0.000	0.000	0.234	1.410	10.245	13.071	13.071
n-Pentane	5.537	9.929	0.000	0.551	1.433	5.280	34.252	48.193	48.193
Trans-2-pentene	4.300	8.913	0.000	0.000	0.060	3.190	26.364	39.063	39.063
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	1.680	3.068	0.000	0.004	0.189	1.707	8.132	13.614	13.614
2,3-Dimethylbutane	2.860	5.157	0.000	0.009	0.397	2.661	14.312	25.406	25.406
2-Methylpentane	1.993	3.246	0.000	0.119	0.370	2.040	9.939	14.645	14.645
3-Methylpentane	1.315	2.122	0.000	0.072	0.242	1.379	6.722	8.556	8.556
1-Hexene	1.449	2.688	0.000	0.018	0.146	1.243	8.662	11.879	11.879
n-Hexane	5.820	12.290	0.000	0.000	0.583	6.245	33.058	72.014	72.014
Trans-3-methyl-2-pentene	0.335	0.794	0.000	0.000	0.038	0.232	1.454	4.980	4.980
2,2-Dimethylpentane	0.153	0.254	0.000	0.000	0.020	0.219	0.795	0.975	0.975
Methylcyclopentane	2.012	3.585	0.000	0.027	0.231	1.913	10.903	14.895	14.895
2,4-Dimethylpentane	0.392	0.695	0.000	0.008	0.070	0.348	1.961	3.426	3.426
2,2,3-Trimethylbutane	0.382	0.744	0.000	0.000	0.032	0.357	2.195	3.482	3.482
Cis-4,4-dimethylpentene	0.422	0.801	0.000	0.000	0.045	0.452	2.545	3.661	3.661
Benzene	0.553	0.944	0.000	0.000	0.174	0.659	2.613	5.317	5.317
3,3-Dimethylpentane	0.421	0.797	0.000	0.000	0.042	0.408	2.369	3.374	3.374
Cyclohexane	0.742	1.381	0.000	0.000	0.107	0.593	3.815	7.018	7.018
2-Methylhexane	0.357	0.572	0.000	0.036	0.106	0.352	1.587	2.557	2.557
2,3-Dimethylpentane	0.431	0.727	0.000	0.018	0.085	0.467	2.195	3.248	3.248
3-Methylhexane	0.608	1.019	0.000	0.030	0.137	0.561	2.865	4.513	4.513
3-Ethylpentane	0.264	0.472	0.000	0.009	0.041	0.289	1.318	2.227	2.227
1-Heptene	0.356	0.845	0.000	0.003	0.055	0.310	1.649	5.461	5.461
2,2,4-Trimethylpentane	0.240	0.500	0.000	0.000	0.043	0.182	1.005	2.901	2.901
n-Heptane	0.309	0.532	0.000	0.037	0.084	0.260	1.493	2.357	2.357
Methylcyclohexane	0.265	0.466	0.000	0.015	0.048	0.224	1.391	2.136	2.136
2,5-Dimethylhexane	0.087	0.148	0.000	0.006	0.017	0.088	0.447	0.623	0.623
2,4-Dimethylhexane	0.067	0.133	0.000	0.010	0.016	0.063	0.263	0.829	0.829
3,3-Dimethylhexane	0.083	0.143	0.000	0.003	0.016	0 101	0.436	0.560	0.560
2,3,4-Trimethylpentane	0.111	0.248	0.000	0.007	0.034	0.108	0.447	1.640	1.640
Toluene	0.267	0.229	0.000	0.105	0.215	0.376	0.818	0.920	0.920
2-Methylheptane	0.079	0.173	0.000	0.010	0.024	0.080	0.263	1.161	1.161
3,4-Dimethylhexane	0.117	0.205	0.000	0.004	0.021	0.106	0.593	0.906	0.906
3-Methylheptane	0.092	0.161	0.000	0.016	0.032	0.113	0.386	0.981	0.981
2,2,5-Trimethylhexane	0.098	0.172	0.000	0.004	0.019	0.077	0.528	0.691	0.691
n-Octane	0.073	0.107	0.000	0.011	0.026	0.082	0.361	0.478	0.478
Ethylbenzene	0.067	0.078	0.001	0.021	0.046	0.089	0.160	0.513	0.513
m-Xylene	0.007	0.041	0.000	0.000	0.000	0.000	0.014	0.293	0.293
p-Xylene	0.145	0.104	0.000	0.061	0.133	0.202	0.340	0.369	0.369
o-Xylene	0.054	0.040	0.000	0.024	0.045	0.071	0.123	0.182	0.182
n-Nonane	0.032	0.048	0.000	0.001	0.019	0.043	0.146	0.222	0.222
Isopropylbenzene	0.049	0.158	0.000	0.003	0.007	0.030	0.246	1.069	1.069
Ethyltoluene	0.032	0.031	0.000	0.014	0.023	0.039	0.090	0.162	0.162
1,3,5-Trimethylbenzene	0.033	0.030	0.000	0.014	0.024	0.041	0.101	0.130	0.130
n-Decane	0.095	0.153	0.000	0.008	0.037	0.093	0.484	0.748	0.748
Total-Hydrocarbons	45.187	69.737	0.021	5.328	10.728	44.404	181.173	324.652	324.652

TABLE A4-2. DESCRIPTIVE STATISTICS OF LONG TERM PERSONAL SAMPLES FOR PUMPERS (NO. OF SAMPLES=91)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	5.583	29.640	0.000	0.304	0.647	1.503	3.659	198.836	204.788
Isobutane	14.088	65.158	0.000	1.184	2.564	5.482	17.071	329.540	532.143
1-Butene	1.448	4.191	0.000	0.131	0.667	1.268	3.247	14.787	37.384
n-Butane	11.445	30.718	0.000	1.981	4.850	10.907	30.323	112.442	271.483
Trans-2-butene	1.411	3.654	0.000	0.000	0.439	1.546	4.494	13.324	31.075
Cis-2-butene	1.107	3.561	0.000	0.239	0.511	0.963	2.332	3.946	33.956
3-Methyl-1-butene	1.197	2.622	0.000	0.000	0.255	0.954	4.872	13.104	14.574
Isopentane	10.208	32.200	0.000	2.106	5.035	8.722	19.587	42.999	306.743
1-Pentene	2.573	5.684	0.000	0.223	0.624	1.316	13.924	20.686	37.690
2-Methyl-1-butene	1.214	3.405	0.000	0.000	0.086	0.758	5.326	13.683	25.684
n-Pentane	10.272	15.344	0.370	3.612	5.672	10.073	29.590	47.094	125.744
Trans-2-pentene	4.145	10.137	0.000	0.183	0.753	1.991	18.810	43.868	66.904
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	1.688	3.410	0.000	0.168	0.496	1.299	6.926	16.143	19.933
2,3-Dimethylbutane	2.714	5.090	0.000	0.265	0.764	2.263	10.015	25.324	28.345
2-Methylpentane	3.250	5.103	0.000	0.977	1.608	3.328	9.735	18.629	39.023
3-Methylpentane	2.009	3.245	0.099	0.544	0.952	2.010	6.466	12.616	23.883
1-Hexene	1.364	2.924	0.000	0.042	0.295	0.922	5.445	13.726	15.951
n-Hexane	8.011	16.801	0.000	0.138	1.079	7.442	33.079	80.838	107.197
Trans-3-methyl-2-pentene	0.332	0.590	0.000	0.055	0.136	0.258	1.668	2.704	2.977
2,2-Dimethylpentane	0.234	0.494	0.000	0.016	0.040	0.183	1.008	2.245	3.179
Methylcyclopentane	2.104	3.925	0.000	0.311	0.665	1.560	7.749	19.771	19.905
2,4-Dimethylpentane	0.403	0.702	0.000	0.084	0.175	0.295	1.897	3.651	3.853
2,2,3-Trimethylbutane	0.295	0.714	0.000	0.000	0.044	0.173	1.291	3.570	3.939
Cis-4,4-dimethylpentene	0.356	0.817	0.000	0.000	0.053	0.237	1.452	4.031	4.609
Benzene	1.079	1.964	0.000	0.196	0.615	1.094	2.647	9.309	15.242
3,3-Dimethylpentane	0.398	0.829	0.000	0.006	0.091	0.269	1.718	3.954	4.278
Cyclohexane	0.569	1.057	0.000	0.000	0.188	0.511	2.669	4.711	5.499
2-Methylhexane	0.544	0.839	0.000	0.163	0.315	0.531	1.509	3.173	6.223
2,3-Dimethylpentane	0.468	0.757	0.000	0.094	0.225	0.403	1.711	4.066	4.130
3-Methylhexane	0.742	1.167	0.033	0.190	0.338	0.688	2.210	5.481	6.182
3-Ethylpentane	0.320	0.564	0.004	0.059	0.114	0.255	1.247	2.468	3.301
1-Heptene	0.303	0.522	0.000	0.017	0.138	0.313	1.159	2.763	3.084
2,2,4-Trimethylpentane	0.250	0.363	0.000	0.000	0.160	0.328	0.863	1.733	2.141
n-Heptane	0.427	0.613	0.034	0.109	0.195	0.457	1.374	2.919	3.018
Methylcyclohexane	0.301	0.551	0.000	0.042	0.092	0.257	1.135	2.992	3.159
2,5-Dimethylhexane	0.102	0.158	0.004	0.025	0.047	0.090	0.387	0.803	0.829
2,4-Dimethylhexane	0.072	0.098	0.000	0.021	0.039	0.068	0.242	0.460	0.533
3,3-Dimethylhexane	0.083	0.152	0.000	0.010	0.032	0.065	0.287	0.799	0.836
2,3,4-Trimethylpentane	0.174	0.243	0.000	0.025	0.072	0.198	0.720	0.828	1.090
Toluene	0.684	1.366	0.021	0.198	0.436	0.755	1.649	2.510	12.707
2-Methylheptane	0.089	0.116	0.008	0.030	0.047	0.093	0.270	0.542	0.664
3,4-Dimethylhexane	0.115	0.225	0.000	0.004	0.048	0.088	0.436	1.163	1.197
3-Methylheptane	0.120	0.168	0.008	0.036	0.060	0.123	0.424	0.791	1.020
2,2,5-Trimethylhexane	0.093	0.178	0.000	0.007	0.040	0.072	0.343	0.951	0.959
n-Octane	0.093	0.134	0.001	0.026	0.044	0.097	0.322	0.714	0.726
Ethylbenzene	0.146	0.198	0.005	0.039	0.074	0.166	0.466	0.862	1.370
m-Xylene	0.015	0.086	0.000	0.000	0.000	0.000	0.005	0.352	0.738
p-Xylene	0.252	0.404	0.000	0.102	0.166	0.274	0.500	1.241	3.576
o-Xylene	0.128	0.267	0.008	0.038	0.068	0.122	0.278	1.288	2.187
n-Nonane	0.224	1.149	0.000	0.006	0.015	0.046	0.243	7.141	8.375
Isopropylbenzene	0.227	0.536	0.000	0.005	0.014	0.056	1.487	1.914	2.995
Ethyltoluene	0.177	0.718	0.000	0.022	0.040	0.075	0.216	4.357	5.239
1,3,5-Trimethylbenzene	0.220	0.928	0.001	0.021	0.037	0.071	0.225	5.553	6.695
n-Decane	0.642	2.773	0.000	0.015	0.045	0.106	0.587	15.502	18.855
Total-Hydrocarbons	96.510	208.111	4.859	26.984	43.823	85.077	242.811	619.722	1842.713

TABLE A4-3. DESCRIPTIVE STATISTICS OF ALL SHORT TERM PERSONAL SAMPLES (NO. OF SAMPLES=114)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	5.566	7.568	0.000	0.936	2.478	7.552	22.232	36.234	36.390
Isobutane	24.921	36.633	0.009	4.515	12.738	30.233	69.982	183.788	250.580
1-Butene	4.958	8.451	0.000	0.754	2.700	6.751	13.241	30.210	77.178
n-Butane	45.459	62.506	0.142	9.715	26.663	57.119	127.173	295.963	448.147
Trans-2-butene	4.771	9.177	0.000	0.000	0.000	6.975	17.891	43.420	66.886
Cis-2-butene	3.348	3.247	0.000	0.948	2.393	4.811	9.297	12.646	19.729
3-Methyl-1-butene	2.708	5.018	0.000	0.183	1.050	2.490	10.979	29.614	30.133
Isopentane	41.418	46.059	0.000	13.253	25.065	55.581	128.391	234.383	247.363
1-Pentene	5.278	9.166	0.000	0.596	2.249	5.344	21.061	41.935	67.783
2-Methyl-1-butene	2.969	5.773	0.000	0.000	1.023	3.279	9.746	30.249	39.678
n-Pentane	40.700	50.952	0.516	13.225	23.773	54.041	123.795	272.292	364.865
Trans-2-pentene	8.671	16.464	0.000	0.605	3.892	10.237	36.520	74.244	128.283
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	4.070	6.411	0.000	0.491	1.805	3.818	15.229	33.610	36.802
2,3-Dimethylbutane	6.932	10.215	0.000	1.195	3.381	7.468	29.787	52.457	54.415
2-Methylpentane	13.334	24.363	0.000	3.560	6.431	12.830	38.398	90.387	207.819
3-Methylpentane	7.606	13.346	0.000	2.022	3.725	7.607	23.843	51.004	110.858
1-Hexene	2.632	4.197	0.000	0.316	1.108	2.843	10.566	17.610	27.823
n-Hexane	16.775	30.662	0.000	1.801	4.663	12.809	66.189	153.114	184.861
Trans-3-methyl-2-pentene	0.804	0.967	0.000	0.184	0.437	1.096	2.447	3.990	6.221
2,2-Dimethylpentane	0.700	3.018	0.000	0.063	0.148	0.364	1.594	8.056	31.044
Methylcyclopentane	5.516	8.507	0.000	1.088	2.658	5.466	20.520	41.917	60.761
2,4-Dimethylpentane	1.127	1.395	0.000	0.261	0.612	1.295	3.738	6.713	8.892
2,2,3-Trimethylbutane	0.473	0.901	0.000	0.001	0.101	0.493	2.283	3.940	6.007
Cis-4,4-dimethylpentene	0.577	1.099	0.000	0.000	0.095	0.511	3.004	4.500	6.880
Benzene	3.210	4.039	0.000	0.943	1.921	3.477	10.722	20.538	21.174
3,3-Dimethylpentane	0.704	1.147	0.000	0.039	0.294	0.810	2.737	4.880	7.573
Cyclohexane	1.516	2.773	0.000	0.115	0.477	1.333	6.840	11.926	18.484
2-Methylhexane	2.082	3.289	0.000	0.667	1.080	2.109	6.370	14.423	26.117
2,3-Dimethylpentane	1.277	1.629	0.004	0.283	0.658	1.754	3.876	6.765	11.758
3-Methylhexane	2.316	3.365	0.000	0.699	1.184	2.447	8.728	17.706	22.425
3-Ethylpentane	0.732	0.985	0.000	0.203	0.354	0.766	2.640	5.705	5.958
1-Heptene	0.803	1.123	0.000	0.074	0.332	0.826	3.188	5.266	5.462
2,2,4-Trimethylpentane	0.787	1.147	0.000	0.000	0.215	1.185	3.018	4.869	5.616
n-Heptane	1.293	2.006	0.000	0.362	0.624	1.305	4.697	8.573	15.382
Methylcyclohexane	0.742	1.180	0.000	0.150	0.339	0.672	2.568	6.093	8.288
2,5-Dimethylhexane	0.274	0.370	0.000	0.073	0.138	0.282	1.004	1.810	2.302
2,4-Dimethylhexane	0.216	0.242	0.000	0.073	0.117	0.275	0.601	1.084	1.332
3,3-Dimethylhexane	0.185	0.247	0.000	0.033	0.091	0.200	0.736	0.876	1.459
2,3,4-Trimethylpentane	0.614	1.227	0.000	0.062	0.196	0.563	3.314	5.153	9.351
Toluene	2.546	3.728	0.017	0.525	1.176	2.665	9.717	19.708	20.143
2-Methylheptane	0.262	0.340	0.000	0.082	0.152	0.293	0.797	1.528	2.424
3,4-Dimethylhexane	0.301	0.953	0.000	0.025	0.106	0.285	0.823	1.842	9.867
3-Methylheptane	0.327	0.431	0.000	0.101	0.176	0.361	1.084	2.099	2.841
2,2,5-Trimethylhexane	0.164	0.233	0.000	0.024	0.081	0.196	0.655	0.995	1.435
n-Octane	0.200	0.224	0.000	0.058	0.125	0.250	0.631	0.959	1.394
Ethylbenzene	0.368	0.442	0.000	0.087	0.180	0.484	1.209	1.904	2.275
m-Xylene	0.046	0.144	0.000	0.000	0.000	0.000	0.435	0.669	0.695
p-Xylene	0.690	0.935	0.000	0.161	0.358	0.790	2.664	4.199	4.646
o-Xylene	0.237	0.306	0.001	0.063	0.123	0.273	0.859	1.359	1.574
n-Nonane	0.045	0.127	0.000	0.001	0.009	0.038	0.130	0.823	0.952
Isopropylbenzene	0.178	0.428	0.000	0.006	0.019	0.055	1.259	1.764	2.307
Ethyltoluene	0.151	0.628	0.000	0.019	0.048	0.104	0.343	0.596	6.659
1,3,5-Trimethylbenzene	0.068	0.089	0.000	0.019	0.034	0.071	0.222	0.474	0.522
n-Decane	0.025	0.075	0.000	0.000	0.004	0.020	0.070	0.460	0.581
Total-Hydrocarbons	273.670	294.938	4.895	103.674	186.250	321.999	750.352	1356.879	2067.149

TABLE A4-4. DESCRIPTIVE STATISTICS OF SHORT TERM PERSONAL SAMPLES FOR REGULAR LEADED GASOLINE(NO. OF SAMPLES=37)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	5.093	7.926	0.052	0.745	1.926	4.468	22.232	36.234	36.234
Isobutane	22.353	42.240	0.009	3.636	10.194	24.508	61.866	250.580	250.580
1-Butene	3.778	5.547	0.000	0.517	2.197	4.264	11.881	30.210	30.210
n-Butane	46.481	78.090	0.142	6.634	26.640	45.032	102.171	448.147	448.147
Trans-2-butene	3.328	6.419	0.000	0.000	0.000	4.397	14.768	31.817	31.817
Cis-2-butene	3.085	3.497	0.000	0.703	2.308	4.388	6.962	19.729	19.729
3-Methyl-1-butene	2.099	3.433	0.000	0.000	0.783	2.437	6.782	16.097	16.097
Isopentane	48.785	60.285	0.712	14.039	23.548	53.778	174.577	247.363	247.363
1-Pentene	4.020	6.061	0.000	0.285	1.961	6.104	16.653	29.530	29.530
2-Methyl-1-butene	1.536	3.094	0.000	0.000	0.050	1.608	8.741	14.286	14.286
n-Pentane	59.282	72.877	0.645	20.620	40.917	57.600	170.196	364.865	364.865
Trans-2-pentene	6.931	12.046	0.000	0.049	1.332	10.237	15.023	52.921	52.921
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	4.516	6.975	0.000	1.002	2.322	3.911	15.229	36.802	36.802
2,3-Dimethylbutane	5.484	9.435	0.000	0.807	3.148	5.311	18.483	54.415	54.415
2-Methylpentane	16.006	34.615	0.000	3.874	8.192	13.237	27.944	207.819	207.819
3-Methylpentane	8.850	18.497	0.000	2.106	4.701	8.109	15.738	110.858	110.858
1-Hexene	1.906	2.692	0.000	0.127	0.939	2.081	6.597	11.037	11.037
n-Hexane	15.985	29.999	0.000	2.731	6.035	9.664	56.778	153.114	153.114
Trans-3-methyl-2-pentene	0.704	0.708	0.000	0.169	0.412	1.096	2.153	2.447	2.447
2,2-Dimethylpentane	1.111	5.073	0.002	0.048	0.132	0.315	1.198	31.044	31.044
Methylcyclopentane	6.134	10.488	0.000	1.510	3.046	5.280	19.896	60.761	60.761
2,4-Dimethylpentane	0.863	1.229	0.000	0.212	0.424	1.059	2.694	6.713	6.713
2,2,3-Trimethylbutane	0.391	0.709	0.000	0.000	0.066	0.526	1.098	3.157	3.157
Cis-4,4-dimethylpentene	0.400	0.747	0.000	0.000	0.063	0.476	1.435	3.161	3.161
Benzene	2.541	3.399	0.000	0.845	1.464	2.488	8.666	17.256	17.256
3,3-Dimethylpentane	0.553	0.812	0.000	0.033	0.247	0.737	1.815	3.517	3.517
Cyclohexane	1.415	2.282	0.000	0.248	0.708	1.229	4.428	11.926	11.926
2-Methylhexane	2.235	4.335	0.000	0.731	1.108	1.983	5.280	26.117	26.117
2,3-Dimethylpentane	0.927	1.305	0.004	0.235	0.447	1.000	3.211	6.765	6.765
3-Methylhexane	2.241	3.832	0.000	0.731	1.275	1.972	6.111	22.425	22.425
3-Ethylpentane	0.743	1.061	0.000	0.272	0.362	0.759	2.302	5.958	5.958
1-Heptene	0.684	0.814	0.000	0.101	0.457	0.756	2.061	3.543	3.543
2,2,4-Trimethylpentane	0.427	0.586	0.000	0.000	0.120	0.650	1.712	1.947	1.947
n-Heptane	1.405	2.589	0.000	0.423	0.772	1.222	3.284	15.382	15.382
Methylcyclohexane	0.879	1.470	0.000	0.204	0.416	0.854	2.568	8.288	8.288
2,5-Dimethylhexane	0.253	0.407	0.000	0.073	0.132	0.253	0.808	2.302	2.302
2,4-Dimethylhexane	0.207	0.275	0.000	0.061	0.103	0.266	0.555	1.332	1.332
3,3-Dimethylhexane	0.160	0.196	0.000	0.043	0.094	0.143	0.568	0.838	0.838
2,3,4-Trimethylpentane	0.343	0.472	0.002	0.041	0.122	0.395	1.237	1.845	1.845
Toluene	1.562	2.309	0.017	0.321	1.018	1.555	4.120	12.667	12.667
2-Methylheptane	0.291	0.415	0.000	0.091	0.196	0.305	0.634	2.424	2.424
3,4-Dimethylhexane	0.432	1.610	0.000	0.017	0.099	0.255	0.835	9.867	9.867
3-Methylheptane	0.338	0.499	0.000	0.099	0.197	0.324	0.853	2.841	2.841
2,2,5-Trimethylhexane	0.130	0.175	0.000	0.015	0.050	0.154	0.420	0.767	0.767
n-Octane	0.190	0.195	0.000	0.077	0.140	0.201	0.584	0.959	0.959
Ethylbenzene	0.271	0.282	0.000	0.075	0.152	0.417	0.761	1.209	1.209
m-Xylene	0.040	0.120	0.000	0.000	0.000	0.000	0.311	0.520	0.520
p-Xylene	0.531	0.757	0.000	0.107	0.357	0.491	2.218	3.746	3.746
o-Xylene	0.181	0.250	0.001	0.034	0.111	0.152	0.740	1.154	1.154
n-Nonane	0.025	0.035	0.000	0.000	0.009	0.031	0.100	0.130	0.130
Isopropylbenzene	0.163	0.356	0.000	0.000	0.017	0.050	1.105	1.277	1.277
Ethyltoluene	0.254	1.088	0.000	0.017	0.035	0.088	0.325	6.659	6.659
1,3,5-Trimethylbenzene	0.058	0.073	0.000	0.020	0.033	0.060	0.198	0.338	0.338
n-Decane	0.015	0.021	0.000	0.000	0.006	0.021	0.053	0.087	0.087
Total-Hydrocarbons	288.615	369.203	4.895	92.146	186.966	308.950	750.352	2067.149	2067.149

TABLE A4-5. DESCRIPTIVE STATISTICS OF SHORT TERM PERSONAL SAMPLES FOR REGULAR UNLEADED GASOLINE(NO. OF SAMPLES=42)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	5.012	6.328	0.000	1.006	2.768	7.552	13.555	36.390	36.390
Isobutane	25.968	33.730	0.041	3.870	12.853	36.457	84.995	183.788	183.788
1-Butene	6.018	12.086	0.000	1.098	2.770	6.815	14.292	77.178	77.178
n-Butane	47.519	58.680	0.750	6.910	26.392	65.840	143.657	295.963	295.963
Trans-2-butene	3.630	5.583	0.000	0.000	0.000	5.421	14.564	19.560	19.560
Cis-2-butene	3.123	2.743	0.000	1.238	2.357	4.591	8.525	12.006	12.006
3-Methyl-1-butene	2.732	5.061	0.000	0.589	1.221	2.881	9.157	30.133	30.133
Isopentane	36.068	33.922	0.698	10.632	30.618	49.756	104.620	148.516	148.516
1-Pentene	4.638	6.189	0.000	0.836	2.685	4.657	21.061	24.322	24.322
2-Methyl-1-butene	2.898	6.369	0.000	0.017	0.922	3.209	7.414	39.678	39.678
n-Pentane	30.414	26.658	0.516	13.159	19.829	46.550	77.116	123.795	123.795
Trans-2-pentene	7.151	10.554	0.000	0.396	4.076	9.595	36.520	44.480	44.480
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	3.881	4.974	0.000	0.586	1.831	5.215	11.807	23.078	23.078
2,3-Dimethylbutane	7.217	8.595	0.000	1.335	3.808	10.125	19.293	38.287	38.287
2-Methylpentane	12.069	17.665	0.000	3.560	6.119	12.360	32.648	90.387	90.387
3-Methylpentane	6.954	9.790	0.064	2.125	3.576	7.607	17.151	49.457	49.457
1-Hexene	2.643	3.249	0.000	0.399	1.380	3.122	8.900	13.167	13.167
n-Hexane	18.253	32.520	0.000	1.584	4.278	26.676	58.117	184.861	184.861
Trans-3-methyl-2-pentene	0.784	0.757	0.008	0.195	0.444	1.432	2.237	3.033	3.033
2,2-Dimethylpentane	0.428	0.649	0.000	0.090	0.193	0.521	1.223	3.673	3.673
Methylcyclopentane	5.144	5.959	0.000	1.006	2.658	8.033	16.836	24.949	24.949
2,4-Dimethylpentane	1.111	1.148	0.050	0.265	0.755	1.643	2.893	5.200	5.200
2,2,3-Trimethylbutane	0.511	0.768	0.000	0.000	0.120	0.493	2.283	2.597	2.597
Cis-4,4-dimethylpentene	0.603	0.907	0.000	0.000	0.119	0.673	2.556	3.298	3.298
Benzene	3.424	4.069	0.000	1.017	2.183	3.952	8.291	21.174	21.174
3,3-Dimethylpentane	0.710	0.912	0.000	0.039	0.357	0.826	2.710	3.379	3.379
Cyclohexane	1.336	2.222	0.000	0.043	0.502	1.884	3.589	11.555	11.555
2-Methylhexane	2.094	2.841	0.016	0.667	1.107	2.534	5.396	14.423	14.423
2,3-Dimethylpentane	1.217	1.199	0.072	0.280	0.698	2.151	3.180	5.233	5.233
3-Methylhexane	2.242	2.691	0.000	0.676	1.111	3.292	5.922	12.507	12.507
3-Ethylpentane	0.683	0.748	0.000	0.186	0.354	0.963	1.795	3.418	3.418
1-Heptene	1.057	1.438	0.000	0.113	0.358	1.609	3.727	5.462	5.462
2,2,4-Trimethylpentane	0.654	0.860	0.000	0.000	0.243	1.018	2.454	3.075	3.075
n-Heptane	1.210	1.562	0.011	0.343	0.534	1.631	3.456	7.248	7.248
Methylcyclohexane	0.662	0.852	0.000	0.148	0.325	0.672	2.014	4.091	4.091
2,5-Dimethylhexane	0.277	0.337	0.006	0.072	0.133	0.340	0.741	1.723	1.723
2,4-Dimethylhexane	0.200	0.214	0.009	0.075	0.114	0.275	0.551	0.989	0.989
3,3-Dimethylhexane	0.195	0.218	0.000	0.029	0.096	0.382	0.566	0.806	0.806
2,3,4-Trimethylpentane	0.674	1.215	0.008	0.068	0.167	0.493	3.599	5.153	5.153
Toluene	2.580	3.573	0.037	0.525	1.082	2.731	9.717	17.851	17.851
2-Methylheptane	0.255	0.291	0.003	0.083	0.125	0.326	0.797	1.258	1.258
3,4-Dimethylhexane	0.232	0.252	0.000	0.019	0.119	0.411	0.707	0.823	0.823
3-Methylheptane	0.320	0.369	0.000	0.102	0.158	0.456	1.073	1.625	1.625
2,2,5-Trimethylhexane	0.169	0.194	0.000	0.024	0.093	0.253	0.545	0.663	0.663
n-Octane	0.199	0.195	0.000	0.056	0.118	0.339	0.538	0.814	0.814
Ethylbenzene	0.389	0.452	0.000	0.087	0.183	0.496	1.361	1.862	1.862
m-Xylene	0.040	0.142	0.000	0.000	0.000	0.000	0.435	0.669	0.669
p-Xylene	0.672	0.841	0.000	0.187	0.355	0.790	2.412	3.987	3.987
o-Xylene	0.225	0.276	0.003	0.063	0.107	0.254	0.774	1.324	1.324
n-Nonane	0.038	0.126	0.000	0.001	0.009	0.036	0.080	0.823	0.823
Isopropylbenzene	0.214	0.522	0.000	0.007	0.021	0.055	1.342	2.307	2.307
Ethyltoluene	0.094	0.135	0.000	0.017	0.048	0.090	0.343	0.596	0.596
1,3,5-Trimethylbenzene	0.062	0.088	0.000	0.017	0.033	0.061	0.165	0.522	0.522
n-Decane	0.024	0.089	0.000	0.000	0.004	0.011	0.057	0.581	0.581
Total-Hydrocarbons	256.915	231.211	6.641	105.632	198.487	322.260	601.788	1122.460	1122.460

TABLE A4-6. DESCRIPTIVE STATISTICS OF SHORT TERM PERSONAL SAMPLES FOR SUPER UNLEADED GASOLINE(NO. OF SAMPLES=35)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	6.729	8.576	0.071	0.931	2.478	9.689	23.231	32.943	32.943
Isobutane	26.379	34.472	0.703	5.962	14.712	30.233	69.982	165.447	165.447
1-Butene	4.932	5.074	0.000	1.043	3.420	7.013	11.782	21.066	21.066
n-Butane	41.908	48.546	1.403	14.439	30.061	49.904	104.613	268.836	268.836
Trans-2-butene	7.664	13.644	0.000	0.000	2.904	9.163	26.757	66.886	66.886
Cis-2-butene	3.895	3.544	0.096	1.032	2.641	5.235	11.668	12.646	12.646
3-Methyl-1-butene	3.324	6.287	0.000	0.232	1.056	2.474	14.382	29.614	29.614
Isopentane	40.051	41.458	0.000	13.284	25.065	56.844	99.398	193.921	193.921
1-Pentene	7.377	13.689	0.000	1.226	3.361	5.449	32.494	67.783	67.783
2-Methyl-1-butene	4.568	6.842	0.000	0.279	2.343	4.959	15.261	30.249	30.249
n-Pentane	33.398	39.830	1.840	11.064	19.286	39.780	82.265	186.925	186.925
Trans-2-pentene	12.334	24.350	0.000	1.570	4.313	10.255	29.086	128.283	128.283
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	3.827	7.413	0.000	0.198	1.413	2.515	21.377	33.610	33.610
2,3-Dimethylbutane	8.122	12.635	0.000	1.312	3.167	7.150	36.437	52.457	52.457
2-Methylpentane	12.028	17.782	0.416	3.297	5.774	10.275	38.398	84.149	84.149
3-Methylpentane	7.073	10.564	0.193	1.840	3.238	5.947	23.843	51.004	51.004
1-Hexene	3.386	6.082	0.000	0.303	1.108	2.294	16.950	27.823	27.823
n-Hexane	15.836	29.871	0.000	1.072	3.976	10.150	66.189	131.494	131.494
Trans-3-methyl-2-pentene	0.935	1.363	0.023	0.163	0.437	0.852	3.513	6.221	6.221
2,2-Dimethylpentane	0.591	1.493	0.000	0.060	0.135	0.340	2.175	8.056	8.056
Methylcyclopentane	5.308	8.976	0.030	0.904	2.024	3.923	23.581	41.917	41.917
2,4-Dimethylpentane	1.425	1.764	0.100	0.391	0.921	1.301	3.914	8.892	8.892
2,2,3-Trimethylbutane	0.515	1.202	0.000	0.009	0.101	0.361	1.768	6.007	6.007
Cis-4,4-dimethylpentene	0.732	1.542	0.000	0.002	0.143	0.503	4.255	6.880	6.880
Benzene	3.659	4.611	0.000	0.994	2.053	3.660	12.987	20.538	20.538
3,3-Dimethylpentane	0.856	1.620	0.000	0.043	0.213	0.681	4.579	7.573	7.573
Cyclohexane	1.839	3.732	0.000	0.000	0.290	1.116	6.840	18.484	18.484
2-Methylhexane	1.905	2.503	0.000	0.615	0.958	1.879	6.370	12.361	12.361
2,3-Dimethylpentane	1.719	2.224	0.131	0.446	0.951	1.763	5.010	11.758	11.758
3-Methylhexane	2.485	3.650	0.039	0.659	1.302	1.997	8.943	17.706	17.706
3-Ethylpentane	0.780	1.163	0.012	0.222	0.313	0.715	3.076	5.705	5.705
1-Heptene	0.623	0.930	0.000	0.022	0.218	0.714	2.557	3.752	3.752
2,2,4-Trimethylpentane	1.327	1.628	0.000	0.000	0.677	2.153	4.517	5.616	5.616
n-Heptane	1.274	1.820	0.050	0.316	0.601	1.034	4.697	8.573	8.573
Methylcyclohexane	0.694	1.198	0.009	0.117	0.263	0.558	2.374	6.093	6.093
2,5-Dimethylhexane	0.292	0.377	0.025	0.063	0.142	0.280	1.035	1.810	1.810
2,4-Dimethylhexane	0.243	0.240	0.014	0.089	0.156	0.289	0.601	1.084	1.084
3,3-Dimethylhexane	0.199	0.323	0.000	0.020	0.074	0.154	0.870	1.459	1.459
2,3,4-Trimethylpentane	0.830	1.691	0.000	0.123	0.333	0.726	3.510	9.351	9.351
Toluene	3.546	4.802	0.145	0.862	1.877	3.321	9.990	20.143	20.143
2-Methylheptane	0.241	0.313	0.018	0.067	0.120	0.228	0.778	1.528	1.528
3,4-Dimethylhexane	0.246	0.411	0.000	0.027	0.093	0.214	1.182	1.842	1.842
3-Methylheptane	0.323	0.434	0.020	0.095	0.170	0.324	1.084	2.099	2.099
2,2,5-Trimethylhexane	0.193	0.317	0.000	0.029	0.082	0.166	0.930	1.435	1.435
n-Octane	0.210	0.282	0.001	0.048	0.104	0.186	0.697	1.394	1.394
Ethylbenzene	0.446	0.550	0.010	0.089	0.206	0.481	1.461	2.275	2.275
m-Xylene	0.059	0.170	0.000	0.000	0.000	0.000	0.472	0.695	0.695
p-Xylene	0.880	1.174	0.000	0.171	0.386	0.910	3.233	4.646	4.646
o-Xylene	0.309	0.381	0.017	0.064	0.167	0.338	1.089	1.574	1.574
n-Nonane	0.073	0.177	0.000	0.004	0.010	0.038	0.315	0.952	0.952
Isopropylbenzene	0.150	0.378	0.000	0.010	0.024	0.053	1.125	1.634	1.634
Ethyltoluene	0.110	0.129	0.000	0.023	0.053	0.144	0.293	0.536	0.536
1,3,5-Trimethylbenzene	0.087	0.103	0.001	0.019	0.048	0.105	0.222	0.474	0.474
n-Decane	0.038	0.090	0.000	0.000	0.003	0.026	0.199	0.460	0.460
Total-Hydrocarbons	277.978	282.324	20.854	112.043	178.751	314.983	746.327	1356.879	1356.879

TABLE A4-7. DESCRIPTIVE STATISTICS OF ALL AREA SAMPLES (NO. OF SAMPLES=160)
(All values in mg/cu. meter)

Component	Mean	Standard Deviation	Minimum	25th Percentile	50th Percentile	75th Percentile	95th Percentile	99th Percentile	Maximum
Propane	0.235	1.591	0.000	0.000	0.018	0.056	0.382	1.813	17.688
Isobutane	1.448	11.079	0.000	0.005	0.022	0.078	0.655	29.924	129.628
1-Butene	0.068	0.380	0.000	0.000	0.011	0.027	0.118	0.688	4.346
n-Butane	2.231	17.903	0.000	0.014	0.045	0.138	1.235	49.602	213.484
Trans-2-butene	0.027	0.151	0.000	0.000	0.000	0.000	0.111	0.585	1.646
Cis-2-butene	0.098	0.663	0.000	0.000	0.000	0.011	0.105	0.904	6.712
3-Methyl-1-butene	0.833	1.873	0.000	0.000	0.078	0.673	5.128	7.425	14.345
Isopentane	1.242	2.996	0.000	0.036	0.306	0.954	4.963	14.591	23.588
1-Pentene	1.473	3.709	0.000	0.000	0.283	1.294	5.642	19.626	30.951
2-Methyl-1-butene	0.877	2.190	0.000	0.000	0.000	0.487	6.158	10.562	12.424
n-Pentane	2.479	6.668	0.000	0.000	0.483	1.968	10.241	27.757	53.808
Trans-2-pentene	2.671	7.479	0.000	0.000	0.243	1.747	12.484	33.573	69.534
2-Methyl-2-butene	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cyclopentane	1.001	2.481	0.000	0.000	0.289	0.837	3.813	10.906	23.580
2,3-Dimethylbutane	1.447	3.718	0.000	0.000	0.366	1.222	5.647	15.920	34.358
2-Methylpentane	1.153	3.778	0.000	0.000	0.266	0.922	3.186	10.236	39.285
3-Methylpentane	0.760	2.289	0.000	0.000	0.191	0.627	2.265	7.029	21.775
1-Hexene	0.819	2.163	0.000	0.000	0.223	0.787	2.842	9.224	21.881
n-Hexane	5.020	10.510	0.000	0.000	0.570	3.921	30.837	43.078	76.242
Trans-3-methyl-2-pentene	0.164	0.432	0.000	0.000	0.035	0.142	0.533	1.564	4.169
2,2-Dimethylpentane	0.130	0.545	0.000	0.000	0.007	0.074	0.509	1.810	6.228
Methylcyclopentane	1.124	3.005	0.000	0.000	0.291	1.013	3.896	11.569	29.784
2,4-Dimethylpentane	0.206	0.534	0.000	0.000	0.045	0.186	0.658	2.226	5.254
2,2,3-Trimethylbutane	0.199	0.585	0.000	0.000	0.042	0.178	0.778	2.357	6.127
Cis-4,4-dimethylpentene	0.231	0.630	0.000	0.000	0.057	0.209	0.817	2.397	6.511
Benzene	0.439	0.943	0.000	0.000	0.063	0.490	1.974	3.786	6.834
3,3-Dimethylpentane	0.237	0.659	0.000	0.000	0.065	0.185	0.885	2.546	6.747
Cyclohexane	0.493	1.146	0.000	0.000	0.050	0.351	3.122	4.353	7.394
2-Methylhexane	0.168	0.411	0.000	0.003	0.052	0.162	0.633	1.574	3.914
2,3-Dimethylpentane	0.266	0.839	0.000	0.000	0.062	0.232	0.760	2.359	8.027
3-Methylhexane	0.307	0.789	0.000	0.000	0.086	0.287	1.190	3.058	8.035
3-Ethylpentane	0.182	0.672	0.000	0.000	0.035	0.129	0.503	1.428	7.405
1-Heptene	0.169	0.435	0.000	0.000	0.044	0.147	0.569	1.666	4.355
2,2,4-Trimethylpentane	0.100	0.279	0.000	0.000	0.013	0.084	0.354	1.032	2.510
n-Heptane	0.279	1.336	0.000	0.002	0.055	0.165	0.628	3.541	15.943
Methylcyclohexane	0.161	0.437	0.000	0.000	0.038	0.149	0.565	1.733	4.503
2,5-Dimethylhexane	0.049	0.126	0.000	0.000	0.013	0.038	0.183	0.514	1.109
2,4-Dimethylhexane	0.030	0.083	0.000	0.000	0.008	0.028	0.095	0.241	0.722
3,3-Dimethylhexane	0.047	0.118	0.000	0.000	0.013	0.045	0.170	0.446	1.221
2,3,4-Trimethylpentane	0.043	0.110	0.000	0.000	0.009	0.038	0.154	0.383	0.892
Toluene	0.202	1.155	0.000	0.013	0.044	0.117	0.423	0.851	14.477
2-Methylheptane	0.036	0.092	0.000	0.000	0.009	0.033	0.135	0.282	0.784
3,4-Dimethylhexane	0.069	0.186	0.000	0.001	0.020	0.072	0.238	0.728	1.972
3-Methylheptane	0.046	0.119	0.000	0.001	0.012	0.040	0.194	0.412	1.053
2,2,5-Trimethylhexane	0.054	0.142	0.000	0.001	0.018	0.052	0.180	0.535	1.510
n-Octane	0.043	0.098	0.000	0.000	0.015	0.046	0.134	0.393	0.980
Ethylbenzene	0.030	0.097	0.000	0.002	0.011	0.030	0.083	0.169	1.163
m-Xylene	0.002	0.006	0.000	0.000	0.000	0.000	0.017	0.025	0.027
p-Xylene	0.059	0.169	0.000	0.006	0.023	0.059	0.164	0.394	1.922
o-Xylene	0.024	0.085	0.000	0.003	0.008	0.020	0.073	0.107	1.049
n-Nonane	0.020	0.059	0.000	0.000	0.000	0.007	0.103	0.271	0.398
Isopropylbenzene	0.017	0.042	0.000	0.000	0.003	0.013	0.088	0.132	0.389
Ethyltoluene	0.015	0.043	0.000	0.000	0.003	0.010	0.063	0.144	0.422
1,3,5-Trimethylbenzene	0.014	0.032	0.000	0.000	0.002	0.010	0.086	0.135	0.188
n-Decane	0.038	0.216	0.000	0.000	0.001	0.010	0.114	0.275	2.464
Total-Hydrocarbons	29.574	71.465	0.041	1.674	9.685	28.283	92.702	250.952	648.553

APPENDIX 5

BULK GASOLINE SAMPLE COMPOSITION

Tables

A5-1 Regular Leaded Gasoline Bulk Sample Composition by Component
(in percent by weight)

A5-2 Regular Unleaded Gasoline Bulk Sample Composition by Component
(in percent by weight)

A5-3 Super Unleaded Gasoline Bulk Sample Composition by Component
(in percent by weight)

Table A5-1. Regular Leaded Gasoline Bulk Sample Composition
(in Percent by weight)

COMPONENT	MEAN	MINIMUM	MAXIMUM
Propane	0.02	0.00	0.16
Isobutane	0.63	0.00	1.79
1-Butene	0.16	0.00	0.52
n-Butane	1.87	0.00	3.53
Trans-2-butene	0.15	0.00	2.34
Cis-2-butene	0.14	0.00	0.49
3-Methyl-1-butene	0.46	0.00	2.55
Isopentane	5.70	0.00	8.85
1-Pentene	0.11	0.00	0.37
2-Methyl-1-butene	0.02	0.00	0.47
n-Pentane	4.94	0.45	7.08
Trans-2-pentene	0.00	0.00	0.00
2-Methyl-2-butene	0.00	0.00	0.00
Cyclopentane	1.44	0.34	1.96
2,3-Dimethylbutane	2.44	0.97	4.10
2-Methylpentane	9.16	4.26	12.52
3-Methylpentane	5.22	2.80	7.11
1-Hexene	0.82	0.25	1.37
n-Hexane	9.53	4.02	12.47
Trans-3-methyl-2-pentene	0.56	0.18	0.94
2,2-Dimethylpentane	0.23	0.00	0.53
Methylcyclopentane	6.90	4.58	8.52
2,4-Dimethylpentane	0.69	0.46	1.00
2,2,3-Trimethylbutane	0.01	0.00	0.05
Cis-4,4-dimethylpentene	0.00	0.00	0.00
Benzene	1.97	0.82	3.33
3,3-Dimethylpentane	0.34	0.11	1.04
Cyclohexane	1.47	0.33	2.52
2-Methylhexane	4.63	3.58	6.51
2,3-Dimethylpentane	1.23	0.88	1.75
3-Methylhexane	4.51	3.18	6.21
3-Ethylpentane	1.44	0.99	1.83
1-Heptene	1.26	0.00	2.55
2,2,4-Trimethylpentane	0.59	0.00	3.23
n-Heptane	4.61	2.05	8.38
Methylcyclohexane	2.31	0.88	4.81
2,5-Dimethylhexane	0.78	0.00	1.45
2,4-Dimethylhexane	0.64	0.36	0.92
3,3-Dimethylhexane	0.38	0.27	0.63
2,3,4-Trimethylpentane	0.63	0.19	1.89
Toluene	5.45	3.11	12.43
2-Methylheptane	1.81	1.13	3.13
3,4-Dimethylhexane	0.24	0.10	0.62
3-Methylheptane	2.01	1.29	3.64
2,2,5-Trimethylhexane	0.20	0.07	0.34
n-Octane	1.42	0.61	3.22
Ethylbenzene	1.50	0.85	3.19
m-Xylene	0.00	0.00	0.08
p-Xylene	4.58	2.88	8.71
o-Xylene	2.00	1.15	3.84
n-Nonane	0.45	0.12	1.43
Isopropylbenzene	0.13	0.04	0.26
Ethyltoluene	1.03	0.44	1.81
1,3,5-Trimethylbenzene	0.97	0.42	1.64
n-Decane	0.22	0.09	0.67

Table A5-2. Regular Unleaded Gasoline Bulk Sample Composition
(in Percent by weight)

COMPONENT	MEAN	MINIMUM	MAXIMUM
Propane	0.03	0.00	0.22
Isobutane	0.60	0.00	1.38
1-Butene	0.24	0.00	0.61
n-Butane	1.94	0.00	5.06
Trans-2-butene	0.29	0.00	1.98
Cis-2-butene	0.22	0.00	0.55
3-Methyl-1-butene	0.93	0.00	5.49
Isopentane	5.31	0.00	8.19
1-Pentene	0.31	0.00	0.65
2-Methyl-1-butene	0.26	0.00	0.75
n-Pentane	2.57	0.17	5.39
Trans-2-pentene	0.41	0.00	1.18
2-Methyl-2-butene	0.00	0.00	0.00
Cyclopentane	0.64	0.00	2.70
2,3-Dimethylbutane	2.85	0.00	5.16
2-Methylpentane	6.54	0.00	9.79
3-Methylpentane	3.79	0.00	5.69
1-Hexene	0.89	0.00	1.60
n-Hexane	4.75	0.26	8.23
Trans-3-methyl-2-pentene	0.51	0.00	0.95
2,2-Dimethylpentane	0.25	0.00	0.60
Methylcyclopentane	3.42	0.00	5.71
2,4-Dimethylpentane	1.34	0.00	5.25
2,2,3-Trimethylbutane	0.01	0.00	0.06
Cis-4,4-dimethylpentene	0.00	0.00	0.00
Benzene	2.23	0.07	5.21
3,3-Dimethylpentane	0.28	0.00	0.58
Cyclohexane	0.40	0.00	1.06
2-Methylhexane	3.92	0.00	5.92
2,3-Dimethylpentane	2.56	0.00	11.03
3-Methylhexane	3.96	0.20	6.14
3-Ethylpentane	0.90	0.00	1.41
1-Heptene	0.28	0.00	1.13
2,2,4-Trimethylpentane	3.42	0.00	16.15
n-Heptane	3.24	0.41	4.96
Methylcyclohexane	1.00	0.23	1.96
2,5-Dimethylhexane	0.83	0.23	1.52
2,4-Dimethylhexane	0.92	0.30	1.81
3,3-Dimethylhexane	0.28	0.13	0.74
2,3,4-Trimethylpentane	1.43	0.08	4.67
Toluene	9.23	3.62	14.63
2-Methylheptane	1.57	0.88	4.49
3,4-Dimethylhexane	0.27	0.10	0.69
3-Methylheptane	1.95	1.02	5.06
2,2,5-Trimethylhexane	0.44	0.03	1.87
n-Octane	1.24	0.62	4.00
Ethylbenzene	2.78	0.66	8.21
m-Xylene	0.00	0.00	0.07
p-Xylene	9.42	2.26	37.14
o-Xylene	4.26	0.90	18.73
n-Nonane	0.49	0.12	2.41
Isopropylbenzene	0.28	0.09	0.94
Ethyltoluene	2.04	0.36	6.94
1,3,5-Trimethylbenzene	1.99	0.50	9.97
n-Decane	0.28	0.04	1.82

Table A5-3. Super Unleaded Gasoline Bulk Sample Composition
(in Percent by weight)

COMPONENT	MEAN	MINIMUM	MAXIMUM
Propane	0.03	0.00	0.19
Isobutane	0.59	0.00	1.49
1-Butene	0.20	0.00	0.80
n-Butane	1.83	0.00	6.26
Trans-2-butene	0.30	0.00	1.87
Cis-2-butene	0.17	0.00	0.51
3-Methyl-1-butene	0.71	0.00	3.20
Isopentane	4.22	0.00	7.86
1-Pentene	0.21	0.00	0.54
2-Methyl-1-butene	0.21	0.00	0.60
n-Pentane	1.79	0.00	3.57
Trans-2-pentene	0.29	0.00	1.00
2-Methyl-2-butene	0.00	0.00	0.00
Cyclopentane	0.31	0.00	2.06
2,3-Dimethylbutane	3.11	0.00	5.32
2-Methylpentane	5.28	0.00	8.51
3-Methylpentane	3.08	0.00	5.22
1-Hexene	0.77	0.00	1.65
n-Hexane	3.39	0.21	6.06
Trans-3-methyl-2-pentene	0.42	0.00	0.95
2,2-Dimethylpentane	0.23	0.00	0.47
Methylcyclopentane	2.36	0.00	4.80
2,4-Dimethylpentane	1.67	0.18	6.84
2,2,3-Trimethylbutane	0.03	0.00	0.12
Cis-4,4-dimethylpentene	0.00	0.00	0.00
Benzene	2.12	0.10	4.88
3,3-Dimethylpentane	0.26	0.00	0.46
Cyclohexane	0.20	0.00	0.49
2-Methylhexane	3.69	1.42	6.15
2,3-Dimethylpentane	3.76	0.98	16.85
3-Methylhexane	3.81	1.64	5.81
3-Ethylpentane	0.76	0.36	1.24
1-Heptene	0.16	0.00	0.62
2,2,4-Trimethylpentane	7.58	0.00	27.96
n-Heptane	3.01	0.81	4.40
Methylcyclohexane	0.63	0.40	1.34
2,5-Dimethylhexane	1.03	0.22	2.04
2,4-Dimethylhexane	1.27	0.15	2.74
3,3-Dimethylhexane	0.22	0.08	0.50
2,3,4-Trimethylpentane	2.95	0.07	8.26
Toluene	12.54	4.21	17.69
2-Methylheptane	1.15	0.37	2.74
3,4-Dimethylhexane	0.25	0.04	0.70
3-Methylheptane	1.50	0.50	3.58
2,2,5-Trimethylhexane	0.51	0.00	1.72
n-Octane	0.85	0.24	2.28
Ethylbenzene	2.84	0.50	7.02
m-Xylene	0.00	0.00	0.00
p-Xylene	9.52	1.76	30.37
o-Xylene	4.20	0.74	13.64
n-Nonane	0.33	0.04	1.42
Isopropylbenzene	0.29	0.08	0.81
Ethyltoluene	1.68	0.35	3.03
1,3,5-Trimethylbenzene	1.54	0.41	4.54
n-Decane	0.15	0.00	0.89